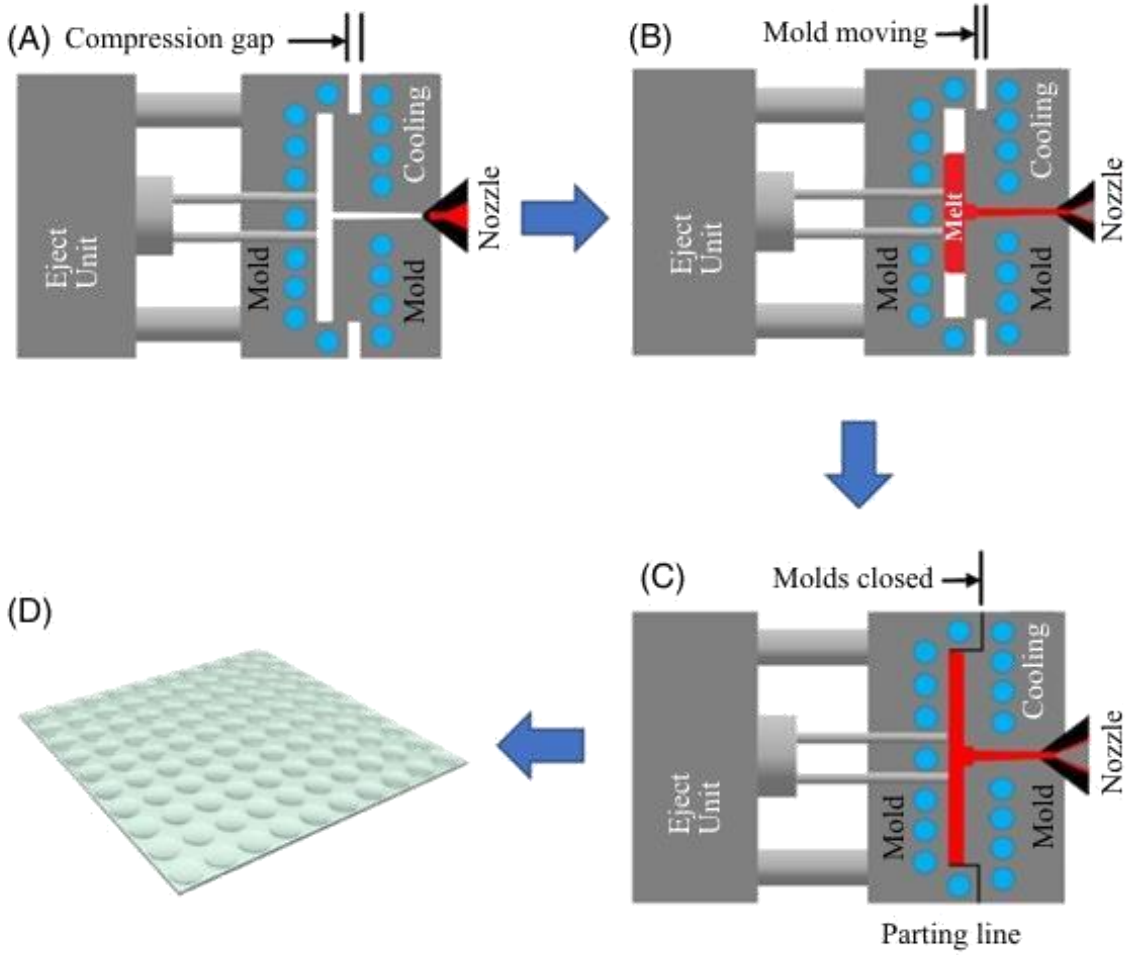
Research Highlights

Prof. Chao-Ming Lin

JOURNAL: Polymers for Advanced Technologies

TOPIC: Injection-compression molding process on optical quality optimization of plastic lens array

ABSTRACT: Plastic lens arrays (PLAs) have the advantages of a light weight and a compact size. However, their optical performance is often degraded by warpage, caused by the accumulation of residual stress during the injection molding process. Accordingly, the present study employs mold flow analysis simulations and a Taguchi-Gray relational analysis (GRA) framework to optimize the processing parameters of the injection compression molding (ICM) process. The analyses focus specifically on the effects of the mold temperature, melt temperature, injection velocity, packing pressure, packing time, and compression gap on the optical path difference (OPD) and lens center displacement (LCD) of the fabricated lens array. The results confirm that the optimized processing parameters significantly improve the OPD, LCD, birefringence, and imaging properties of the PLA compared to those of a PLA fabricated using standard molding conditions.



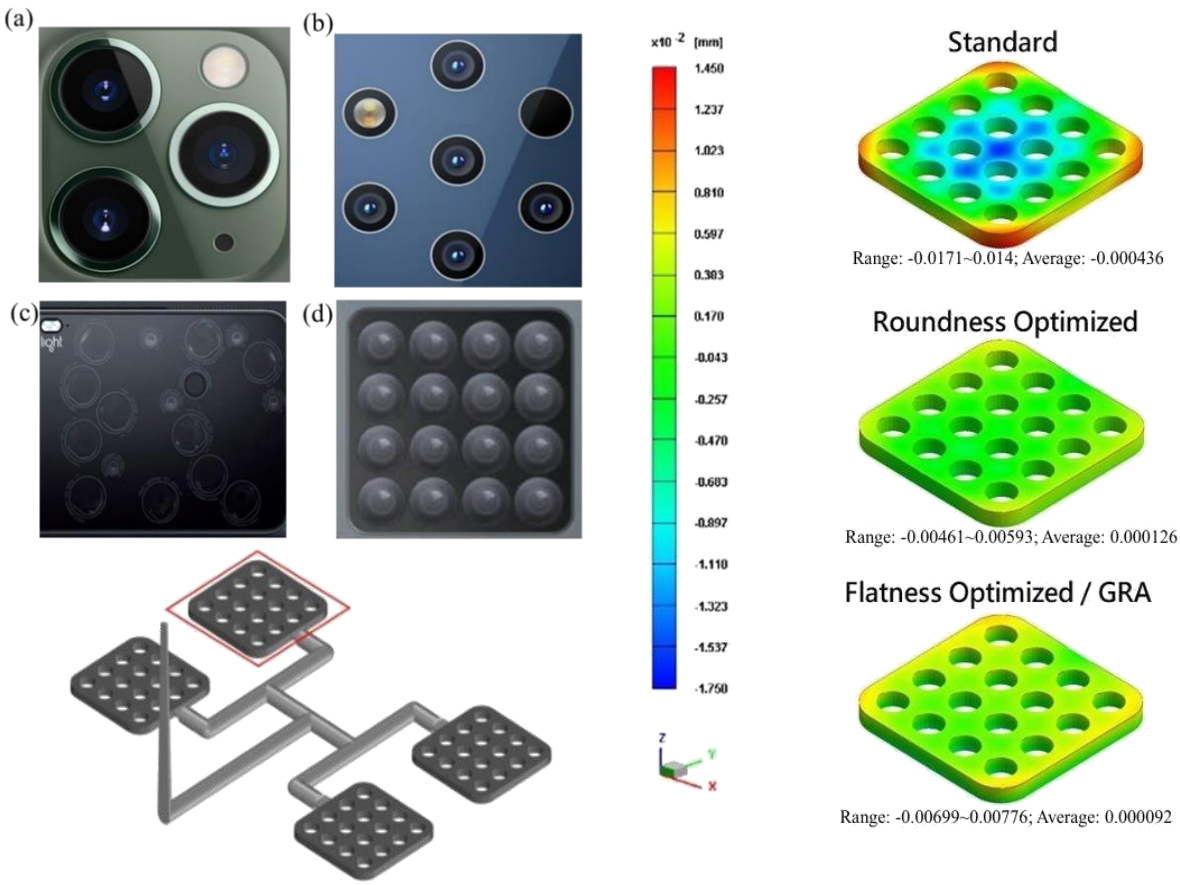
Research Highlights

Prof. Chao-Ming Lin

JOURNAL: Polymers for Advanced Technologies

TOPIC: Taguchi-Gray Relational Analysis of Eccentricity and Tilt of Multi-lens Module Mount Fabricated by Injection Compression Molding

ABSTRACT: This study utilizes the mold flow analysis technique of the injection compression molding (ICM) process, combined with the Taguchi -Gray relational analysis (GRA), for process optimization analysis on the roundness of the lens holes and the flatness of the lens mount in a 4x4 planar multi - lens array mount. After manufacturing simulation analysis, the eccentricity and tilt information of the lens mount was further evaluated optically through spot diagram analysis upon inserting the same glass lenses. The results showed a positive correlation trend between roundness and flatness in structural deformation analysis, indicating that improving the overall flatness of the lens mount can enhance the roundness of the lens holes. In optical analysis, better improvements in the lens tilt angle were achieved through GRA. In conclusion, aiming to simultaneously improve the roundness of the lens holes and the overall flatness of the lens mount, the Taguchi -GRA method can achieve the optimization objectives. In terms of optical performance, by optimizing for roundness, it is possible not only to reduce the diameter of the light spot but also to simultaneously reduce the offset displacement of the light spot center on the screen. The method proposed in this pa per can serve as an analytical model for the design and fabrication of plastic multi-lens mount.



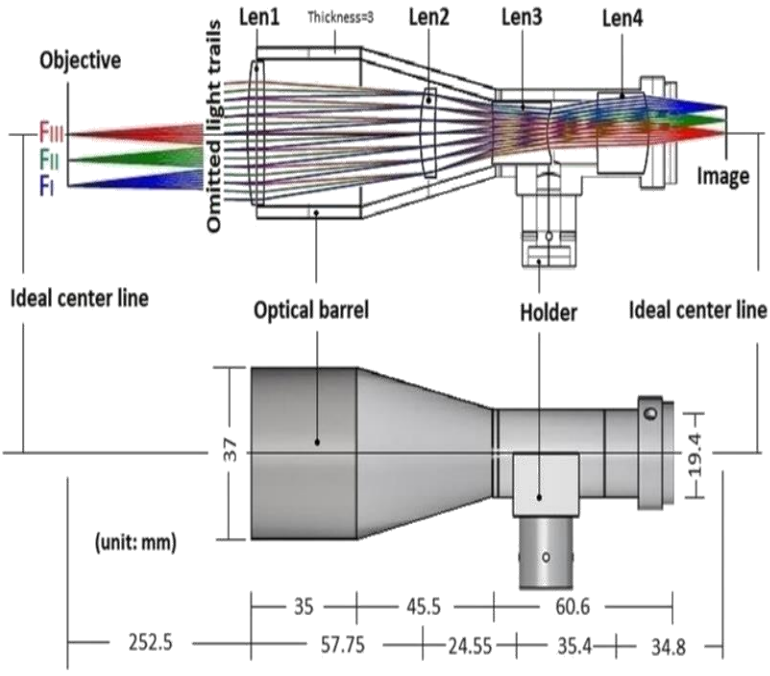
Research Highlights

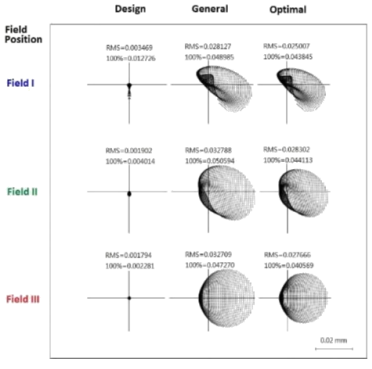
Prof. Chao-Ming Lin

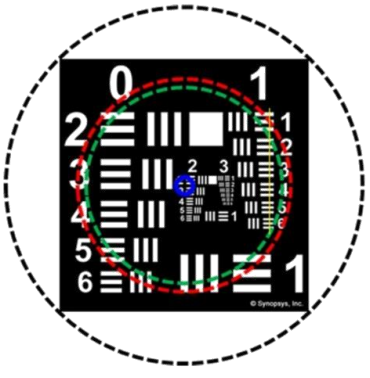
JOURNAL: Symmetry

TOPIC: Coaxiality Optimization Analysis of Plastic Injection Molded Barrel of Bilateral Telecentric Lens

ABSTRACT: Plastic optical components are light in weight, easy to manufacture, and amenable to mass production. However, plastic injection molded parts are liable to shrinkage and warpage as a result of the pressure and temperature variations induced during the mold ing process. Consequently, controlling the process parameters in such a way as to minimize the geometric deformation of the molded part and improve the performance of the optical component as a result remains an important concern. The present study considers the problem of optimizing the injection molding parameters for the plastic lens barrel of a bilateral telecentric lens (BTL) containing four lens assemblies. The study commences by using CODE V optical software to design the lens assemblies and determin e their optimal positions within the barrel. Taguchi experiments based on Moldex3D simulations are then performed to determine the processing conditions (i.e., maximum injection pressure, maximum packing pressure, melt temperature, mold temperature, and co oling time) which minimize the coaxiality of the plastic barrel. Finally, CODE V and grayscale analyses are performed to confirm the optical performance of the optimized BTL. The Taguchi results show that the coaxiality of the plastic lens barrel is determined mainly by the maximum packing pressure and melt temperature. In addition, the CODE V and grayscale analysis results confirm that the optimized BTL yields a better modulus transfer function, spot diagram performance, and image quality than a BTL produced using the general injection molding parameters.







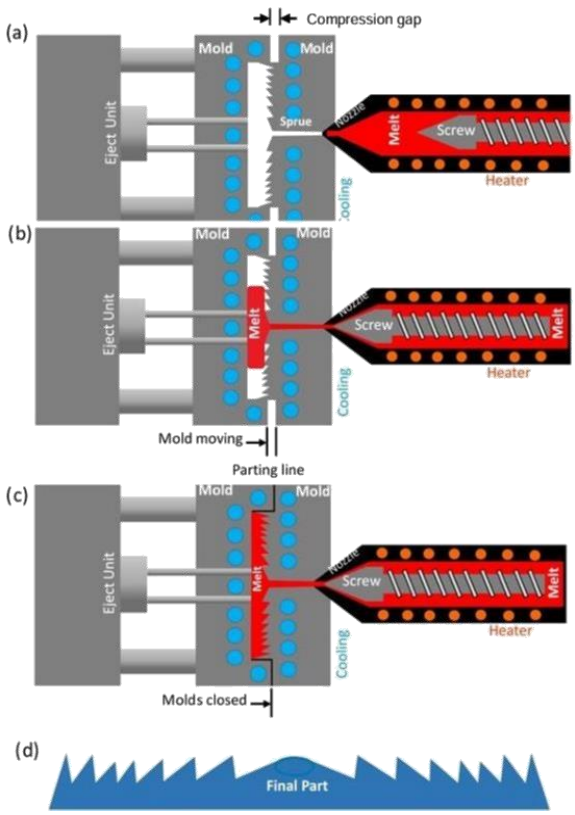
Research Highlights

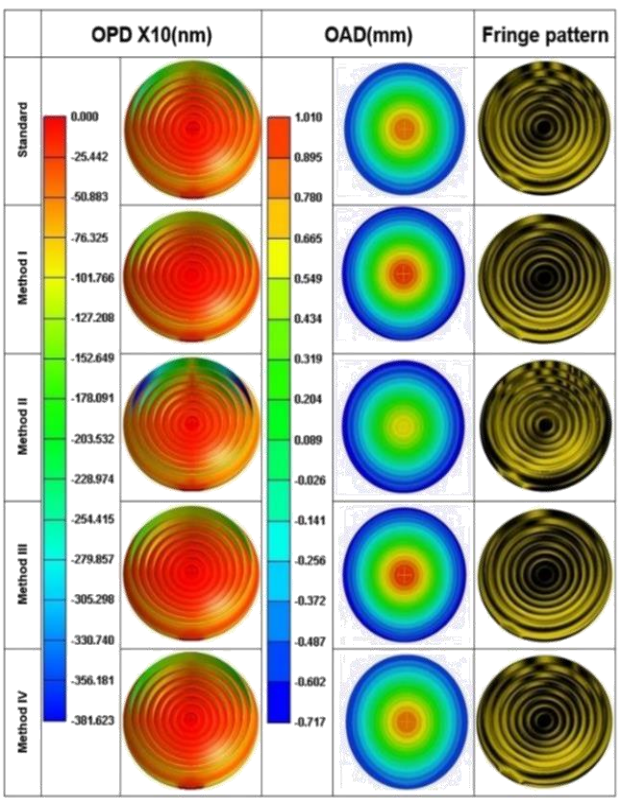
Prof. Chao-Ming Lin

JOURNAL: IEEE ACCESS

TOPIC: Optimization of Injection-Compression Molding Processing Conditions for Fresnel Lens Based on Optical Performance and Geometry Deformation Considerations

ABSTRACT: Mold flow simulations are performed to determine the processing conditions which optimize the optical performance and geometry deformation of a plastic Fresnel lens manufactured using the injection-compression molding (ICM) technique. Due to the quality requirements of plastic optical components in ICM manufacturing (it is hoped to achieve the goals of minimum deformation and minimum birefringence), and pursuing the above two conflicting objectives and meeting the quality requirements at the same time is the best product optimization. The analysis process is to optimize optical path difference and optical axial displacement individually by Taguchi method, and two sets of processing parameters are obtained respectively. Based on these data, a set of processing parameters that can optimize two objectives at the same time is obtained by using the grey relational analysis. If the above process cannot obtain optimal result, the fixed factor method can fix the most significant factor and continue to process the optimization analysis of the remaining factors. The results show that the presented method can indeed solve the problems of dual-objectives optimization and large differences in the influence of factors.





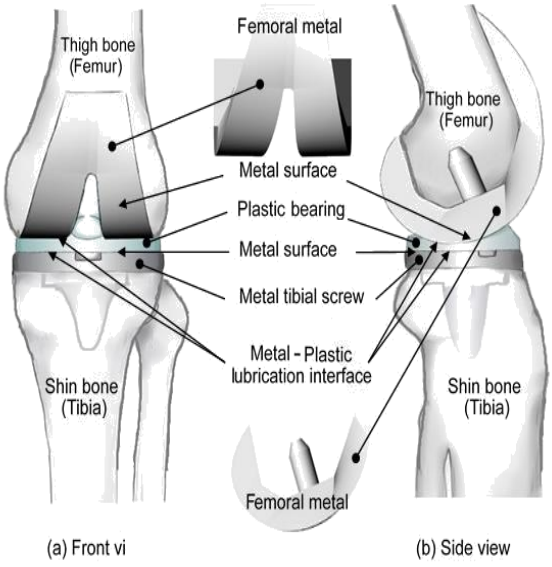
Research Highlights

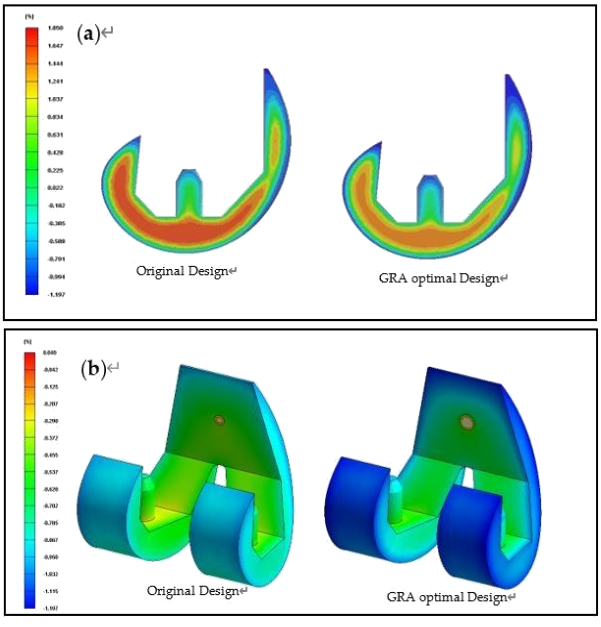
Prof. Chao-Ming Lin

JOURNAL: Polymers

TOPIC: Hybrid Taguchi–Gray Relation Analysis Method for Design of Metal Powder Injection-Molded Artificial Knee Joints with Optimal Powder Concentration and Volume Shrinkage

ABSTRACT: Artificial knee joints play a critical role in improving the quality of life of the elderly and those with knee injuries. Such knee joints are fabricated using a composite material consisting of metal alloy particles and polymer resin and are generally produced using the metal powder injection molding (MIM) process. However, if the local powder concentration of the molded product is too low, the mechanical properti es and aesthetic appearance of the joint are severely degraded. Similarly, if the product undergoes excessive shrinkage following removal from the mold, the dimensional accuracy will fail to meet the design specifications. Accordingly, the present study applies a hybrid approach based on the Taguchi robust design methodology and gray relation analysis (GRA) theory to determine the optimal MIM processing conditions that simultaneously maximize the powder concentration uniformity while minimizing the volume s hrinkage. The feasibility of the proposed approach is demonstrated by means of CAE (Computer Aided Engineering) mold flow simulations. The results show that while the robust Taguchi design method enables the optimal processing parameters that maximize the powder concentration uniformity and minimize the volume shrinkage to be individually determined, the hybrid Taguchi –GRA method enables both quality measures to be optimized simultaneously.





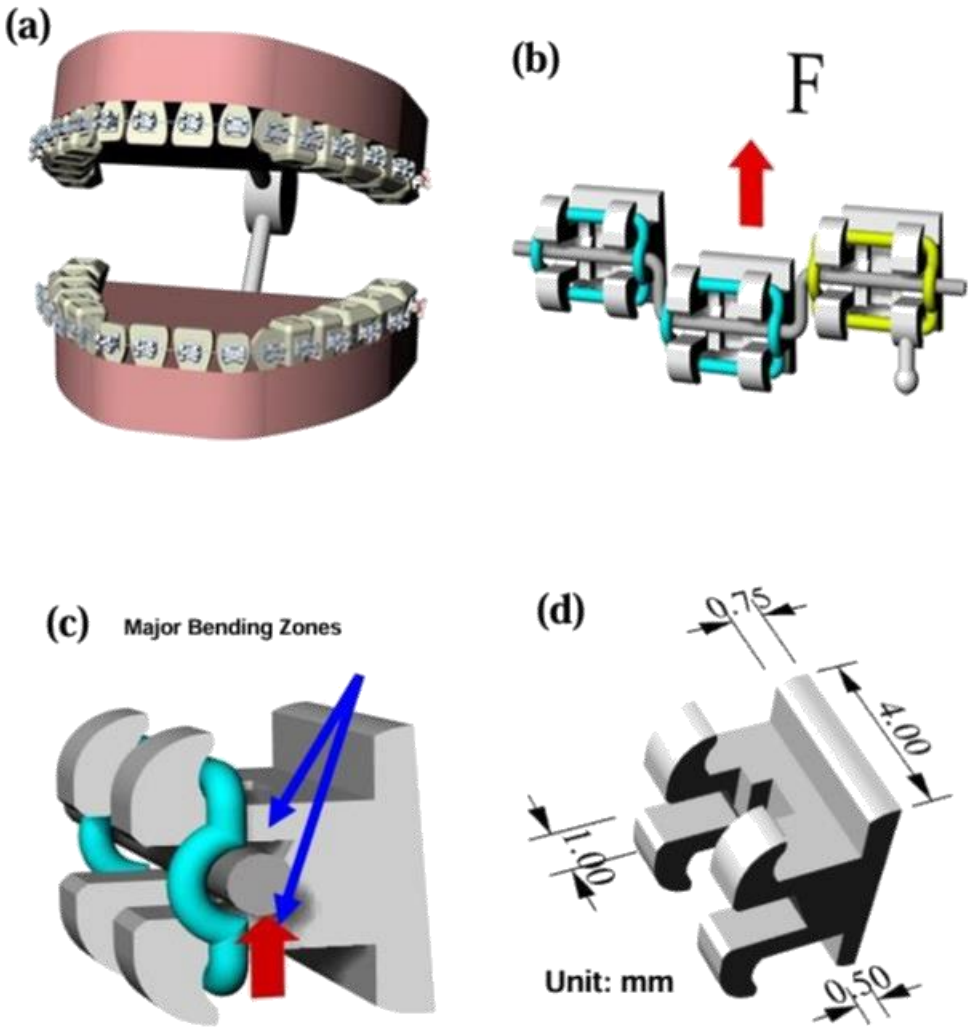
Research Highlights

Prof. Chao-Ming Lin

JOURNAL: Polymers

TOPIC: Processing Optimization for Metal Injection Molding of Orthodontic Braces Considering Powder Concentration Distribution of Feedstock

ABSTRACT: Metal injection molding (MIM) utilizes a compound consisting of metal powder particles and a binding agent as the feedstock material. The present study combines MIM mold flow simulations with the Taguchi method to clarify the individual and combined effects of the main MIM process parameters on the metal powder concentration distribution in the final sintered product. The results show that the molding process should be performed using a short filling time, a high melt temperature, a low packi ng pressure, a low mold temperature, and a small gate size. Given these process settings, the powder concentration uniformity and phase separation effect are significantly improved; giving rise to a better aesthetic appearance of the final sintered productand an enhanced mechanical strength.



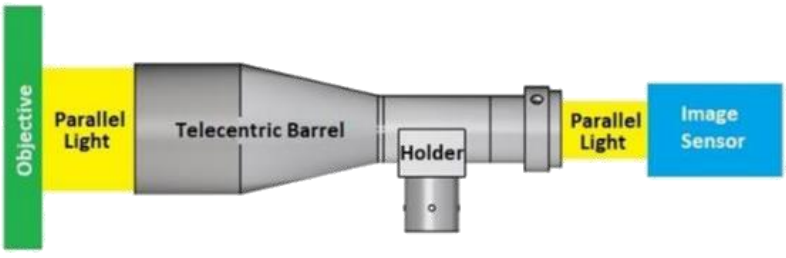
Research Highlights

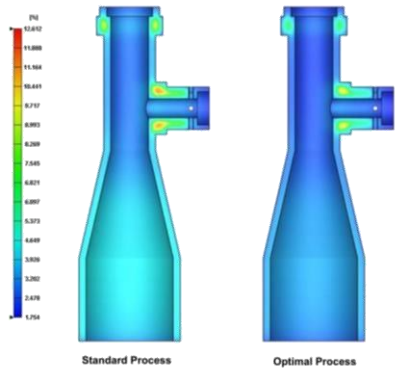
Prof. Chao-Ming Lin

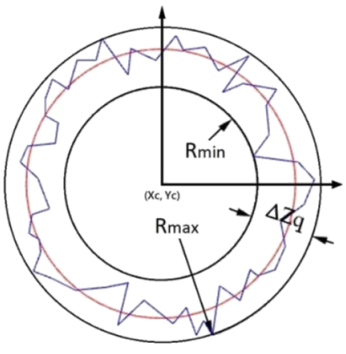
JOURNAL: Polymers

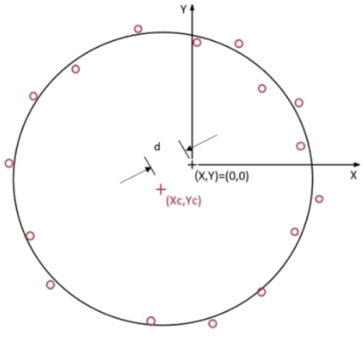
TOPIC: Taguchi Optimization of Roundness and Concentricity of a Plastic Injection Molded Barrel of a Telecentric Lens

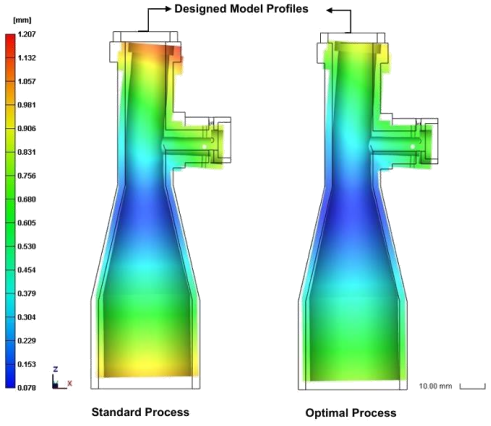
ABSTRACT: Plastic is an attractive material for the fabrication of tubular optical instruments due to its light weight, high strength, and ease of processing. However, for plastic components fabricated using the injection molding technique, roundness and concentricity remain an important concern. For example, in the case of a telecentric lens, concentricity errors of the lens barrel result in optical aberrations due to the deviation of the light path, while roundness errors cause radial stres due to the mismatch of the lens geometry during assembly. Accordingly, the present study applies the Taguchi design methodology to determine the optimal injection molding parameters which simultaneously minimize both the overall roundness and the overall concentricity of the optical barrel. The results show that the geometrical errors of the optical barrel are determined mainly by the melt temperature, the packing pressure and the cooling time. The results also show that the optimal processing parameters reduce the average volume shrinkage rate (from 4.409% to 3.465%) and the average deformations from (0.592 mm to 0.469 mm) of the optical barrel, and the reduction of the corresponding standard deviation values are (from 1.528% to 1.297%) and (from 0.263 mm 0.211 mm), respectively. In addition, the overall roundness and overall concentricity of the barrel in the four planes are positively correlated.











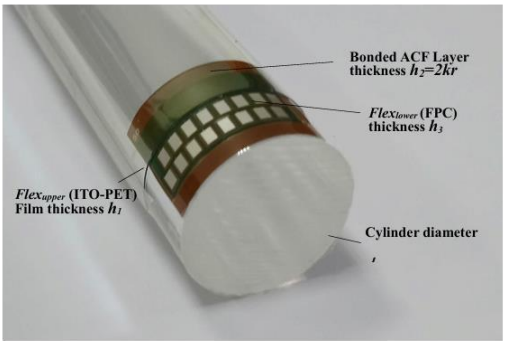
Research Highlights

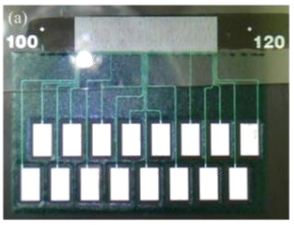
Prof. Chao-Ming Lin

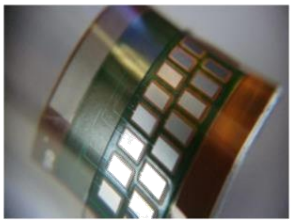
JOURNAL: Microsystem Technologies

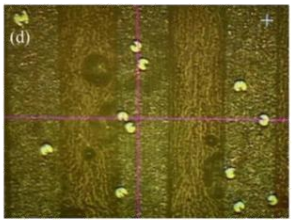
TOPIC: Effects of Bonding Position on Bending Behavior of Flexible Anisotropic Conductive Film Packages considering Neutral Surface

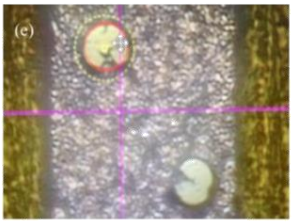
ABSTRACT: A theoretical investigation is performed into the bending behavior of FOFACF (Flex-On-Flex bonded by Anisotropic Conductive Film) packages bonded at different positions relative to the neutral surface position. The stresses and strains produced in the upper and lower regions of the ACF layer are investigated using Mode I fracture mechanics theory. The results show that the region of the ACF layer beneath the neutral surface of the FOF-ACF package experiences a negative stress, which prevents pre-existing cracks in the conductive particles from propagating further. However, at larger distances from the neutral surface, the compressive stress increases to such an extent that it may result in crumbling of the conductive particles. By contrast, the region of the ACF layer above the neutral surface experiences a positive stress, which promotes crack tip propagation. Moreover, the tension stress (i.e., the crack propagation effect) increases with an increasing distance from the neutral surface. The optimum bonding position for the ACF layer is found to be coincident with the neutral surface since, under this condition, the stresses and strains acting on the compressed particles present their minimum values. Consequently, the risk of fracture failure is reduced and the reliability of the ACF package is correspondingly improved.

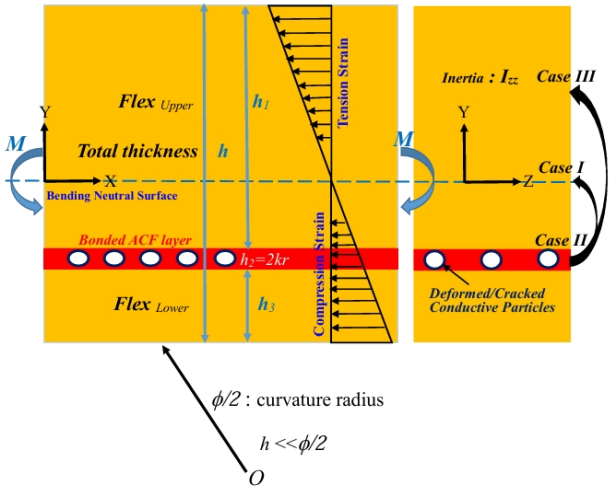












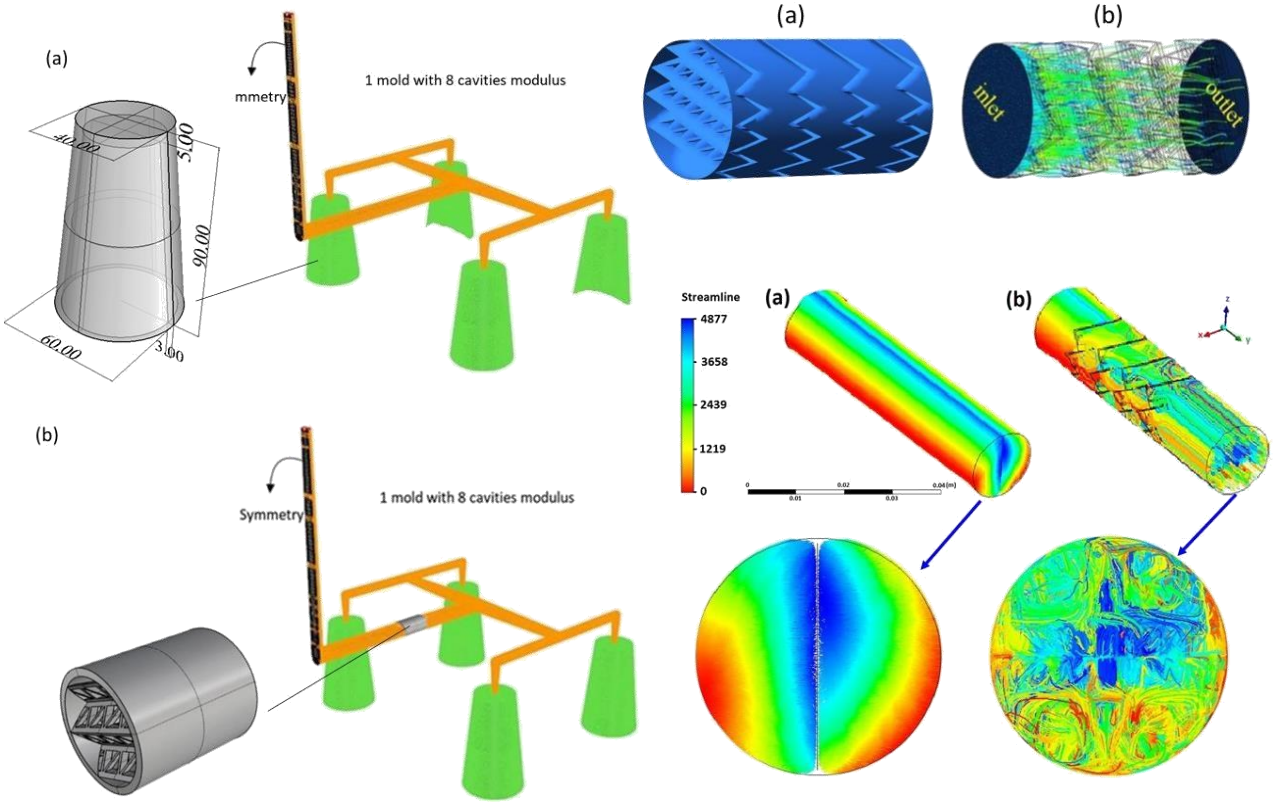
Research Highlights

Prof. Chao-Ming Lin

JOURNAL: Microsystem Technologies

TOPIC: Optimization Designation of Static Mixer Geometry considering Mixing Effect

ABSTRACT: The polymer materials used in the injection molding process have a non -Newtonian characteristic. Consequently, a flow imbalance problem often occurs, even if an H-type runner system is employed. This problem can be addressed by placing a static mixer in the runner. However, the performance of the mixer is highly dependent on its design. Accordingly, the present study employs the Taguchi design methodology to optimize four geometry parameters of the passive mixer, namely the baffle lattice angle (Factor A), the baffle lattice thickness (Factor B), the mixer length (Factor C) and the baffle inset pattern angles (Factor D). For each run in the orthogonal array, the temperature distribution at the mixer outlet is evaluated by Moldex3D simulatio ns. The parameter settings which result in the maximum temperature uniformity (i.e., the minimum signal-to-noise (S/N) ratio) are then taken as the optimal design. The validity of the optimization results is confirmed by means of ANSYS Fluent and Image J s imulations. The Taguchi results show that the optimal parameter settings for the passive mixer are as follows: The Moldex3D simulation results show that the optimal mixer design improves the Taguchi S/N ratio by 1.17 dB compared to the original mixer desig n. Furthermore, the ANSYS Fluent simulations show that the mixing index is improved from 0.5121 (original design) to 0.4213 (optimal design).



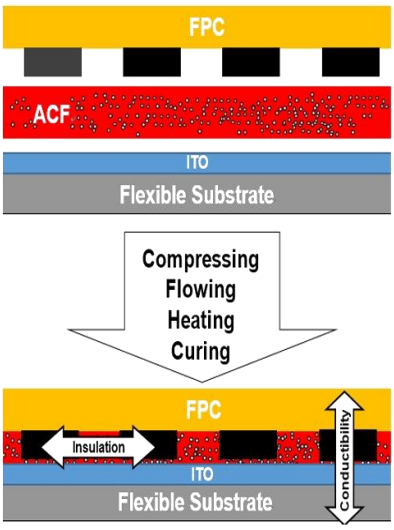
Research Highlights

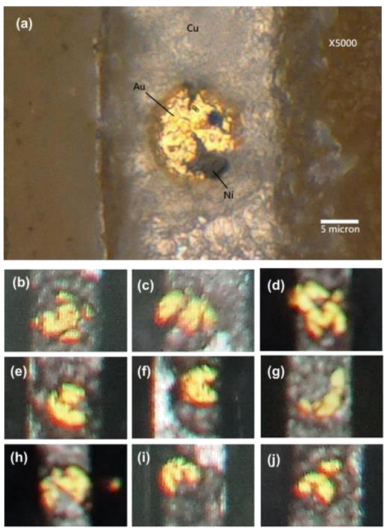
Prof. Chao-Ming Lin

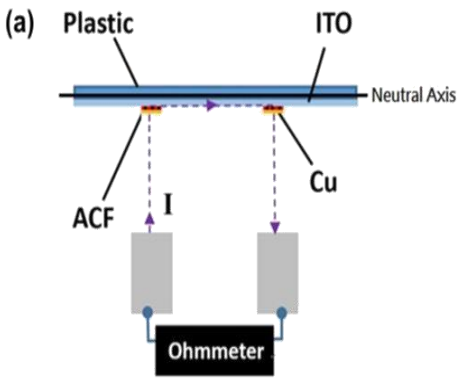
JOURNAL: Microsystem Technologies

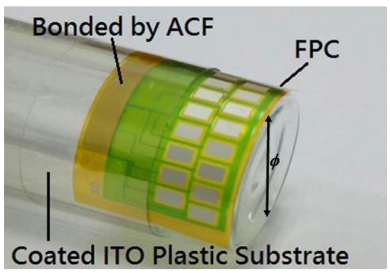
TOPIC: Investigation on Fracture and Conductivity of Flex-On-Film Flexible Bonding using Anisotropic Conductive Film considering Repeated Bending

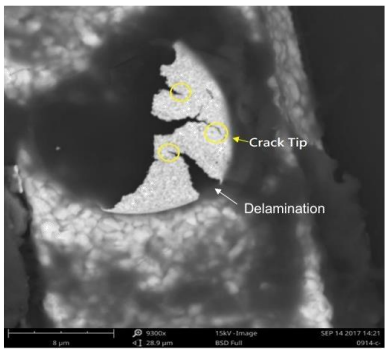
ABSTRACT: This study conducts an experimental investigation into the bending behavior and electrical resistance properties of Flex (PI with Cu) -On-Film (ITO-coated PET) packages considering the flexible effects under static bending loads with sequential bending cycl es. The FOF packages, consisting of flex (with fine -pitch Cu circuits) and film (ITO -coated PET plastic) are bonded by Anisotropic Conductive Film (ACF). During the ACF bonding process, the deformed conductive particles in the adhesive matrix between the Cu electrodes and the ITO film under the effects of the compression force, and these broken conductive particles will play an electrical conductive role. In the subsequent bending tests (loading &unloading with many cycles), the conductive particles experience a compression or tension stress, which causes a further propagation of the cracks formed in the original packaging process. The results show the measured electrical resistance in the specified conductive channel increases with the bending cycles increa sing, and the microscopic observations show that the higher electrical resistance is the result of a smaller overall contact area between the conductive ACF particles and the Cu electrode / ITO film due to fatigue crumbling of the particles.

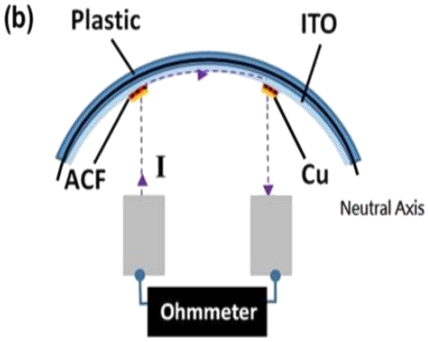












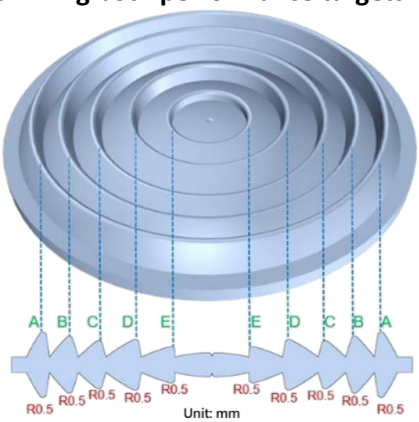
Research Highlights

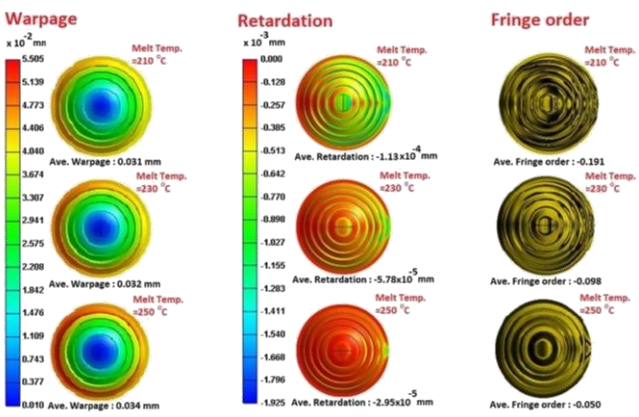
Prof. Chao-Ming Lin

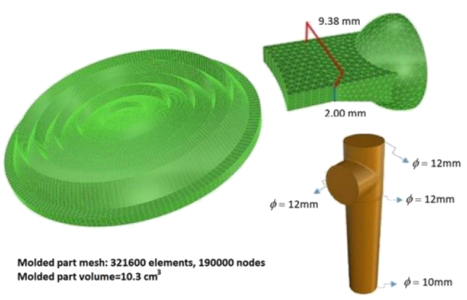
JOURNAL: Microsystem Technologies

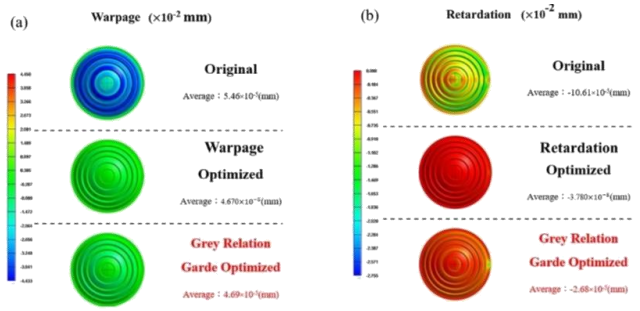
TOPIC: Optimization of Injection-Molding Processing Conditions for Plastic Double-Convex Fresnel Lens Using Grey-based Taguchi Method

ABSTRACT: Injection molding is an ideal technique for the low -cost mass production of plastic optical lenses. However, the optical quality of the lens is significantly dependent on the processing parameters employed in the molding process. In particular, the parameters should be set in such a way as to minimize both the shrinkage displacement -induced warpage (in order to reduce optical aberrations) and the residual stress (in order to reduce the birefringence). However, in practice, the two performance targets are mutually exclusive. That is, a smaller warpage results in a greater residual stress, and vice versa. Thus, in the present study, Taguchi experiments are first performed to determine the processing parameters which individually minimize the warpage and retardation of a symmetric plastic double-convex Fresnel lens, respectively. A grey relational analysis technique is then applied to the Taguchi results to establish the pro cessing parameters which achieve the optimal tradeoff between the two performance objectives. The validity of the proposed method is demonstrated by means of mold-flow analysis simulations. The results show that in simultaneously optimizing both the warpage and the retardation, the injection molding control factors are ranked in order of decreasing influence as follows: packing pressure, packing time, melt temperature, filling time, cooling time and mold temperature. Given the optimal process parameter sett ings, the warpage and retardation are reduced by 16.42% and 74.74%, respectively, compared to the original design. In other words, the proposed grey -based Taguchi method provides a viable technique for optimizing both performance targets for the considered double-convex Fresnel lens.









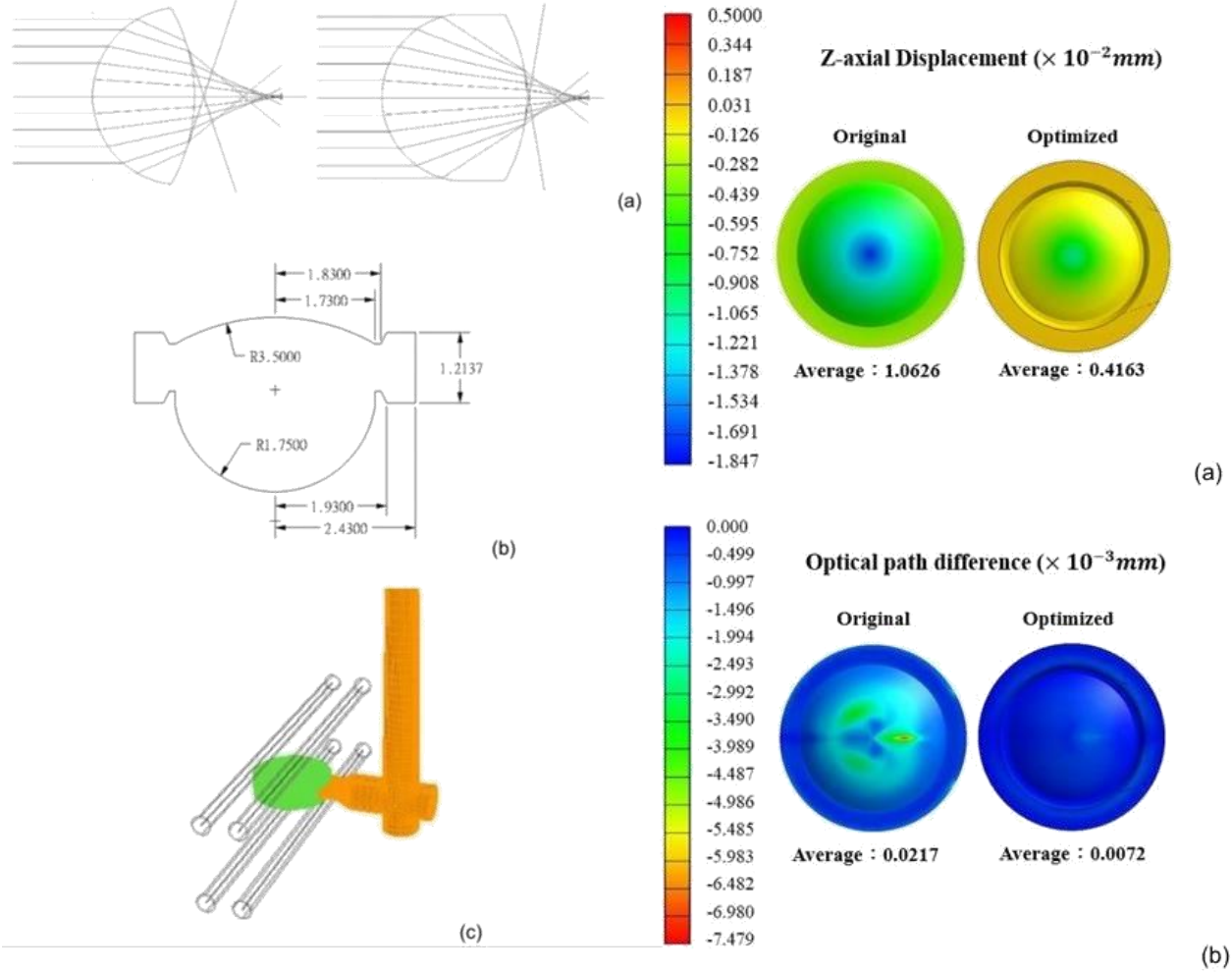
Research Highlights

Prof. Chao-Ming Lin

JOURNAL: Microsystem Technologies

TOPIC: Grey Optimization of Injection Molding Processing of Plastic Optical Lens Based on Joint Consideration of Aberration and Birefringence Effects

ABSTRACT: The optical performance of injection molded plastic lenses is seriously degraded by the warpage and residual stress induced during the molding process. In particular, warpage produces optical aberrations, while residual stress causes birefringence. Consequently, it is essential that the processing parameters used in the molding process are properly assigned. Accordingly, the present study first applies the robust Taguchi design methodology to determine the processing conditions which independently minimize the warpage and residual stress of the molded lens, respectively. The two sets of parameters are then further analyzed using a grey relational analysis model to establish the processing parameters which simultaneously minimize both the warpage and the residual stress. The simulation results confirm that the joint optimization process yields an effective improvement in the quality of the injection molded lens.



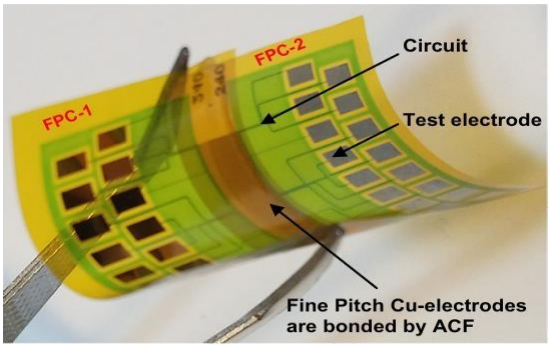
Research Highlights

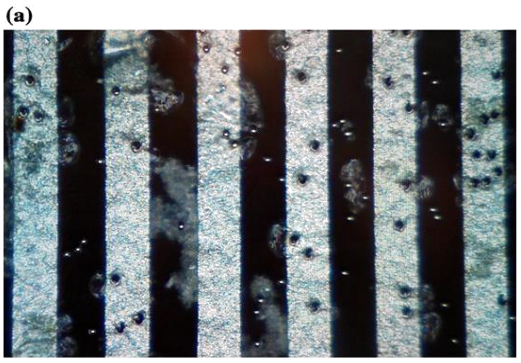
Prof. Chao-Ming Lin

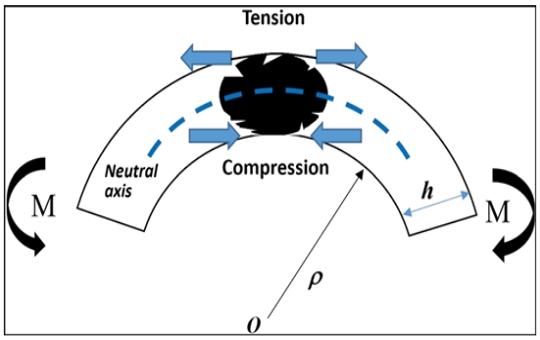
JOURNAL: Microsystem Technologies

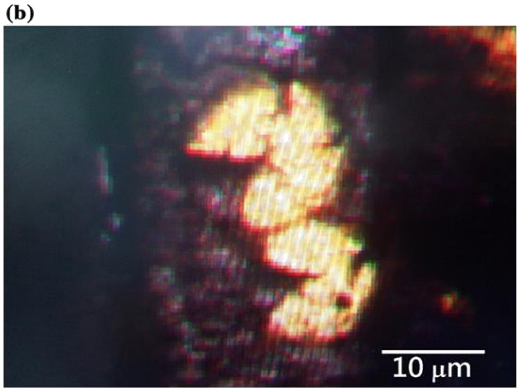
TOPIC: Electrical Resistance Effects of Anisotropic Conductive Film-Assembled Flex-On-Flex Packages under Static Bending Loads

ABSTRACT: An investigation is performed into the change in electrical resistance of Flex -On-Flex (FOF) assemblies under static bending loads. The FOF test vehicles are preparedvia the face-to-face bonding of two identical Flexible Printed Circuits (FPCs) by means of Anisotropic Conductive Film (ACF). The FOF assemblies are then sandwiched between two thin flexible polycarbonate (PC) sheets in order to obtain the required bending radius in the range of 10-50 mm. In each bending test, the electrical resistance of 16 designated ACF conduction channels is measured, recorded and analyzed using a conventional digital ohmmeter. The electrical resistance of the FOF package under different bending radii is interpreted by reference to microscopic observations of the ACF conductive particle distribution within the Cu -electrode gaps and the effects of the bending moment on the deformation and crack damage of the particles, as observed through a microscope. The results show that the electrical resistance is determined mainly by the number of particles within the Cu - electrode gaps. However, the electrical resistance increases slightly with a reducing bending diameter due to the greater bending m oment, which increases the propensity of the conductive particles toward cracking and therefore reduces the contact area between the metallic shell of the particles and the Cu -electrodes. In general, the present results show that the neutral axis of the bending load should be constrained to lie close to the center of the conductive particles, thereby minimizing the stress and strain acting on them and reducing the risk of critical fracture.









Research Highlights

Prof. Chao-Ming Lin

JOURNAL: Microsystem Technologies

TOPIC: Processing optimization of Fresnel lenses manufacturing in the injection molding considering birefringence effect

ABSTRACT: The Taguchi robust design method is used to examine the effects of the processing conditions on the birefringence properties of a Fresnel lens fabricated using a plastic injection molding technique. The Computer Aided Engineering (CAE) simulation results show that the residual stress within the lens is determined (in descending order of influence) by the melt temperature, the filling time, the packing time and the mold temperature. In addition, it is shown that given an appropriate setting of the processing parameters, the average residual stress can be reduced by 75.1%; resulting in a reduction of 74.7% in the average birefringence. In general, the results presented in this study confirm the effectiveness of the integrated Taguchi/CAE approach in optimizing the performance of plastic Fresnel lenses for a variety of focusing applications.

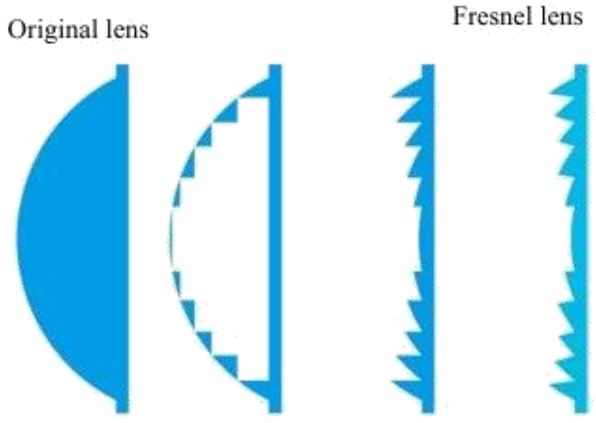


Fig. 1 Fresnel lens shaping process (from *left* to *right*)

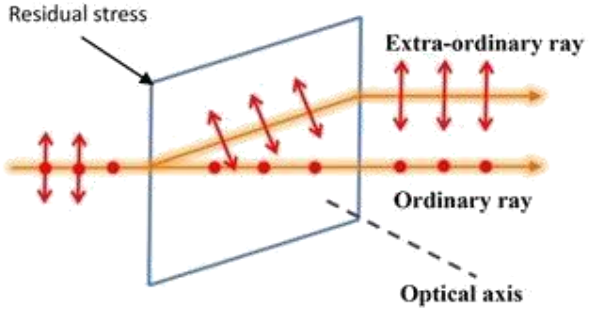
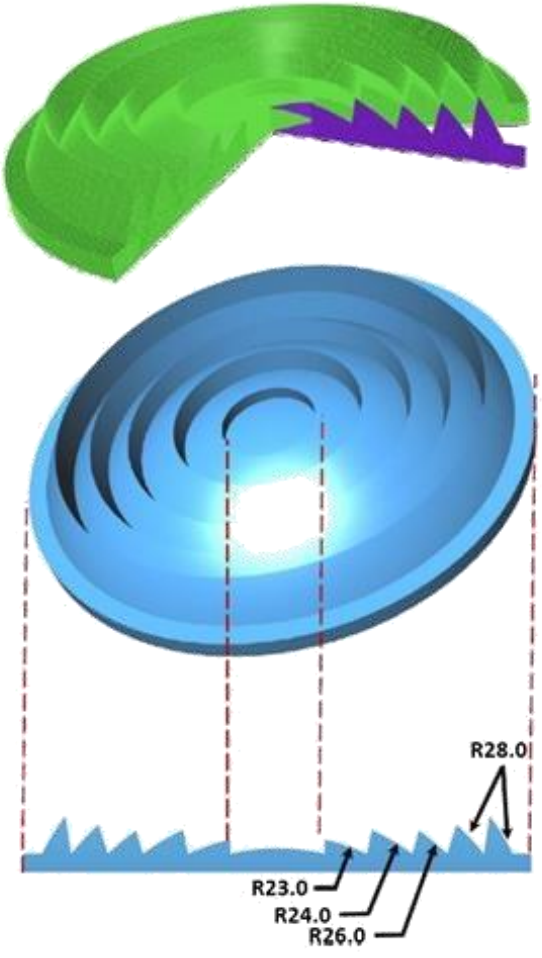


Fig. 2 Effect of residual stress in inducing birefringence in transparent materials



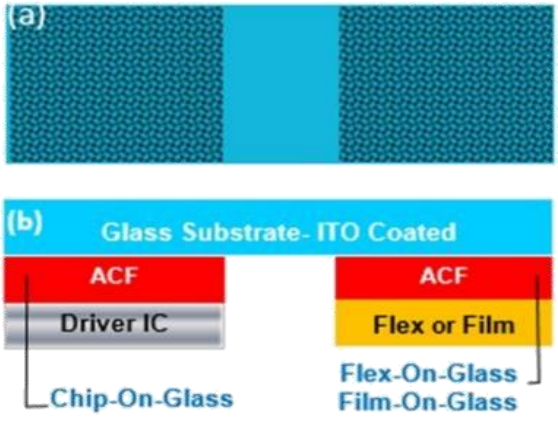
Research Highlights

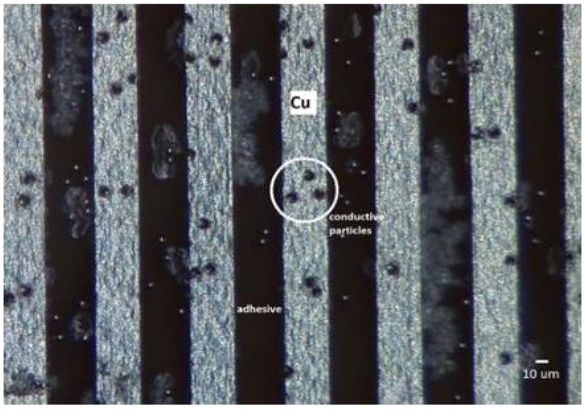
Prof. Chao-Ming Lin

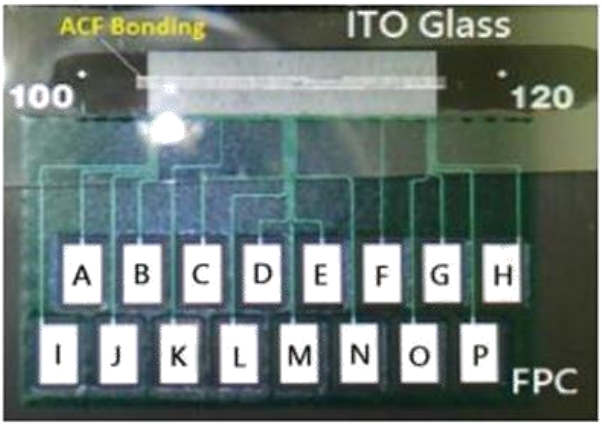
JOURNAL: Materials Science Forum

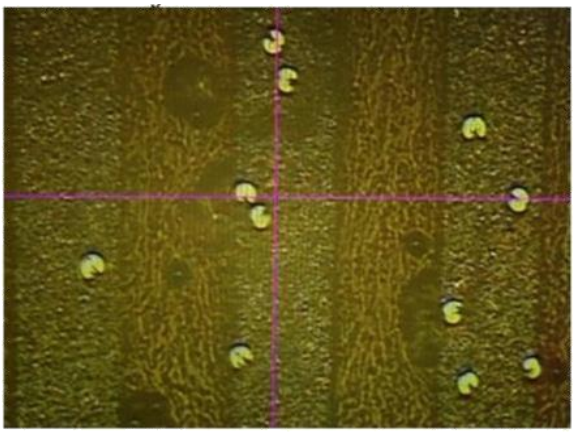
TOPIC: Investigating the Deformation, Breakage and Number on Conductive Particle of Flim-On-Glass Packaging using Anisotropic Conductive Film Bonding

ABSTRACT: Anisotropic conductive film (ACF), is a lead-free material that is commonly used in fine-pitch interconnect manufacturing to make and maintain the electrical and mechanical connections between the micro -electrodes. A key issue about the circuit conductivity is the deformation, breakage, and number of conductive particles in the ACF packaging. For the field of vision, the Film-On-Glass (FOG) assembly on the glass -side is used to obtain excellent images in experimental observation. This paper utilizes the microscope technology to investigate the bonding properties of the conductive particles, and consider the electrical resistance effects after packaging. The results show the deformation shape, breakage type, and number of conductive particles will be quantitatively affect the electrical performances, and one can measure the area, diameter, and roundness of the deformed particles' projection in the glass-side view to evaluate the ACF packaging quality.









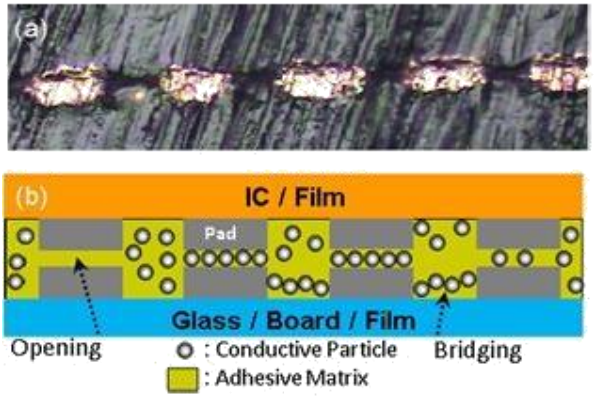
Research Highlights

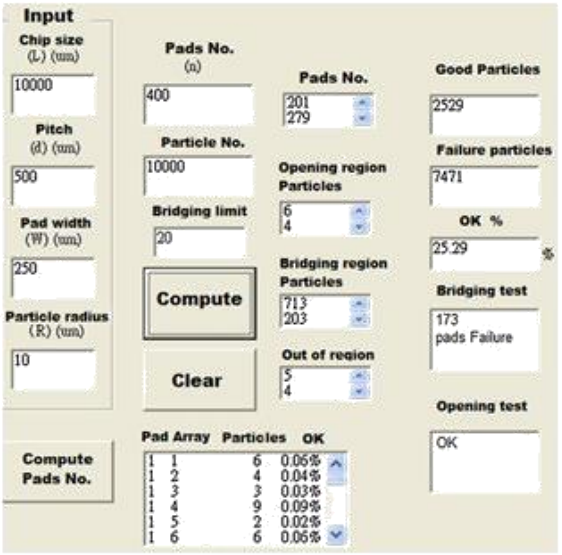
Prof. Chao-Ming Lin

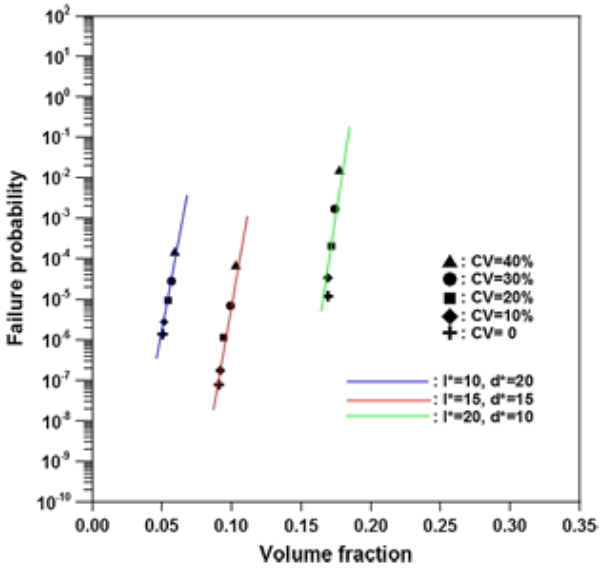
JOURNAL: Microsystem Technologies

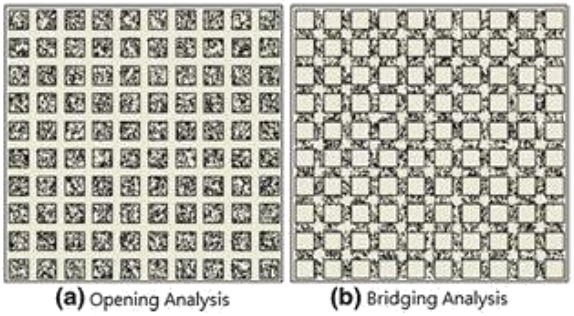
TOPIC: Random dispersion effects of conductive particles on anisotropicconductive film's (ACF's) bonding yield

ABSTRACT: In this study, the authors try to analyze the failure probability of Anisotropic Conductive Film (ACF) packages using V -shaped curve method considering the random effects with random dispersion of conductive particles. It is shown that the dependencies of the coefficient of variation (CV) and the failure probability on the volume fraction are investigated and the results are then used to construct a correlation between the random error and the CV for a specified volume fraction. The results presented in this study have shown that the failure probability and random error are reduced as the value of the volume fraction approaches the values corresponding to the tip of the V -shaped curve. In additional, the V-shaped curves in the failure probabilities are moved from lower to higher with the increasing CV, and the optimal designed volume fraction will linearly increase with increasing CV. Hence, when specifying the composition of the ACF compound with any random error, the volume fraction should be assigned the tip value in order to maximize the reliability of the failure probability









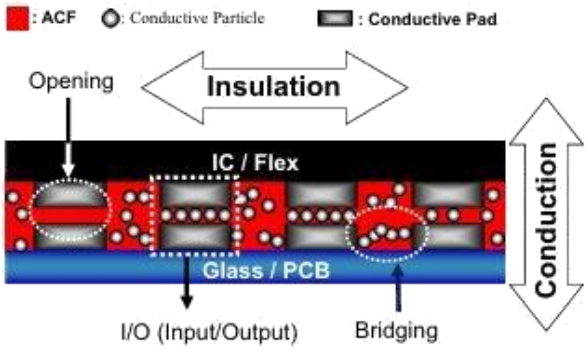
Research Highlights

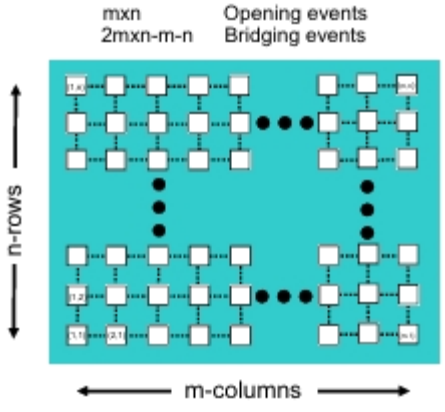
Prof. Chao-Ming Lin

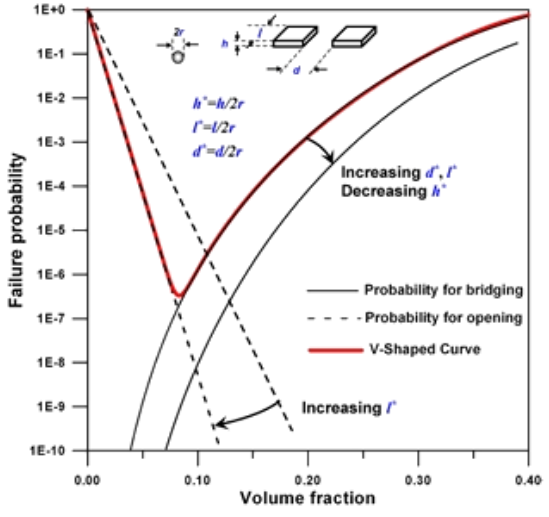
JOURNAL: XXXXXXXXX or unpublished

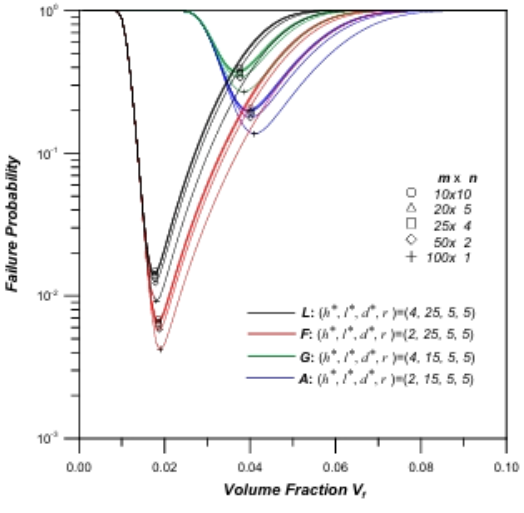
TOPIC: Electric conduction failure of ACF packages based on pad array aspect ratio consideration

ABSTRACT: A mathematical model based on the V-shaped curve method is proposed for estimating the electric conduction failure probability of Anisotropic Conductive Film (ACF) packages with constant I/O number but different pad array aspect ratios. The overall failure probability takes account of both electrical open (opening event modeled using a Poisson function) and short circuit (bridging event modeled using a box model), and is calculated in accordance with the Inclusion – Exclusion principle of combinatorial mathematics. The results show that for a given set of pad geometry parameters, the failure probability decreases monotonically with an increasing pad array aspect ratio. However, the optimal particle volume fraction (i.e., the particle volume fraction which minimizes the overall probability failure) remains approximately constant as the aspect ratio is increased. Moreover, for an ACF package with a specified I/O number and given conductive particle size, the failure probability can be reduced by decreasing the pad height, increasing the pad side length, increasing the pad distance, and setting the ACF volume fraction equal to that corresponding to the tip of the V-shaped curve.









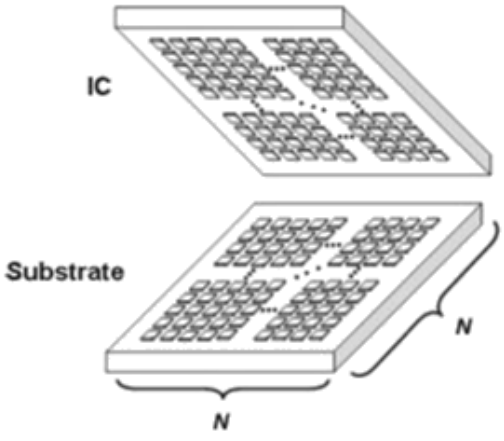
Research Highlights

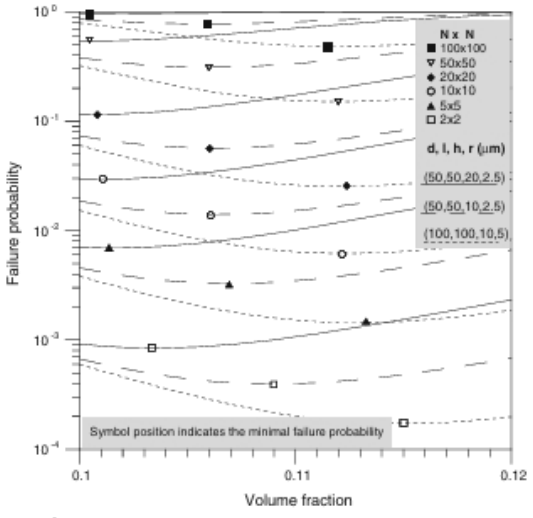
Prof. Chao-Ming Lin

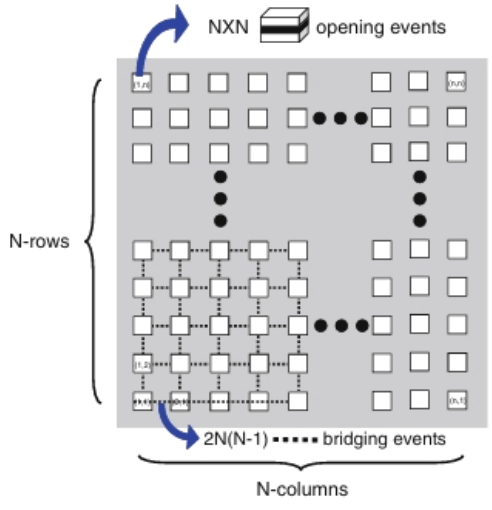
JOURNAL: Journal of Materials Science: Materials in Electronics

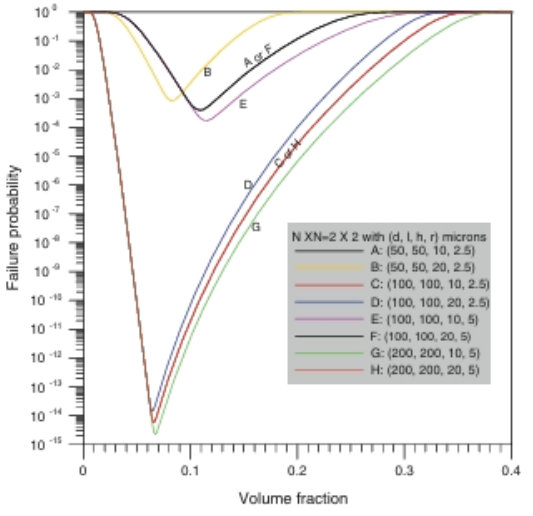
TOPIC: Estimation of ACF packaging failure probability for IC/substrateassemblies with different pad array dimensions

ABSTRACT: An analytical model based on the V-shaped curve method is proposed for estimating the failure probability of anisotropic conductive film (ACF) packages with different padarray dimensions. In analyzing the failure probability of the ACF package, the probability of an opening event in the conductivity direction is modeled as a Poisson distribution, while the probability of a bridging event in the insulation direction is modeled using the enhanced box model. The overall failure probability of the package is then calculated in accordance with the inclusion–exclusion principle of combinatorial mathematics. The results presented in this study suggest that the failure probability of ACF packages with a high pad array dimension can be improved by reducing the pad height, decreasing the conductive particle size, increasing the pad pitch, increasing the pad size, or setting the ACF volume fraction close to the tip of the V-shaped curve.









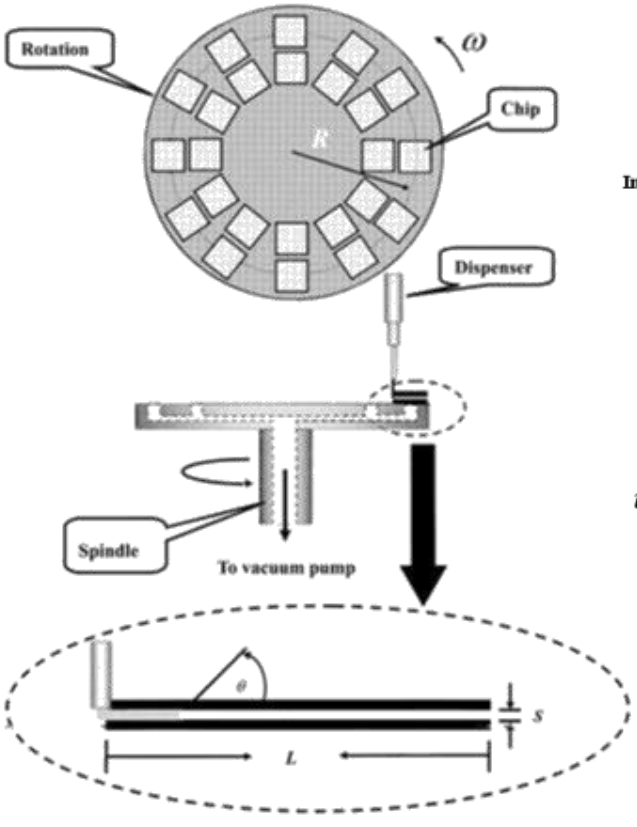
Research Highlights

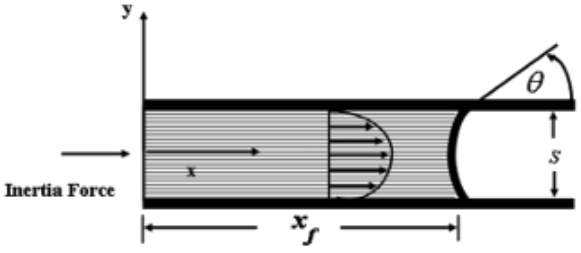
Prof. Chao-Ming Lin

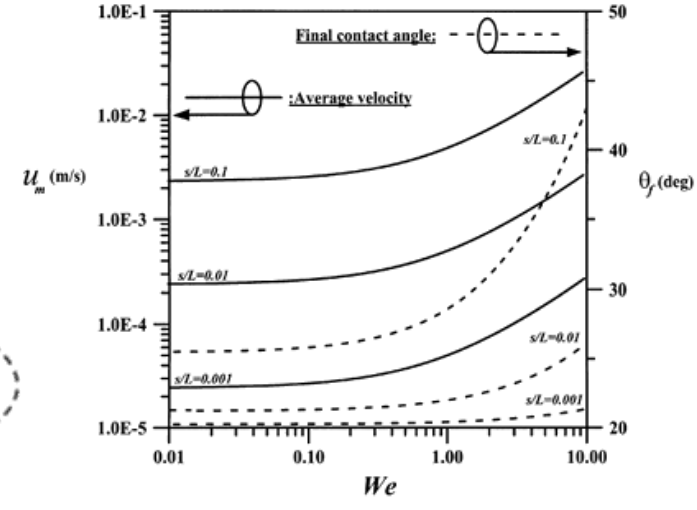
JOURNAL: IEEE TRANSACTIONS ON ADVANCED PACKAGING

TOPIC: Enhancement of Underfill Capillary Flow in Flip-Chip Packaging by Means of the Inertia Effect

ABSTRACT: This paper describes how the use of inertia forces induced by the rotation of a working disk may be adopted to increase the fill rate of the flip-chip packaging process and thereby reduce the process cycle time. It is shown how the driving forces resulting from the inertia effect are determined by the Weber number. The constant and varying contact angle models are compared under a specified set of process conditions. The calculated flow behavior results indicate that the relationship between the contact angle, the average fluid velocity, the liquid-air interface position, and the filling time depends upon the Weber number. The constant and varying contact angle models are utilized in the analysis of a new processing method referred to as rotation-enhanced underfill packaging (REUP). The inertia effect induced by the angular motion of the working disk is shown to enhance the flow of the underfil l encapsulant and to reduce the time of the underfill process. The present results confirm that the rotation of the working disk leads to an increased underfill capillary flow rate, which is beneficial in reducing the production cycle time of the flip - chip packaging process.







Research Highlights

Prof. Chao-Ming Lin

JOURNAL: IEEE TRANSACTIONS ON DEVICE AND MATERIALS RELIABILITY

TOPIC: Effects of Systematic and Stochastic Errors on Estimated Failure Probability of Anisotropic Conductive Film

ABSTRACT: This study analyzes the effects of systematic and stochastic errors on the failure probability of anisotropic conductive film (ACF) assemblies estimated using the V -shaped curve method. It is shown that the effect of systematic errors varies as a function of the absolute value of the volume fraction and the volume fraction bias, respectively. The effects of stochastic errors are investigated by using an in-house software program to generate random conductive particle distributions in the pad and inter-pad regions of the ACF package for given volume fractions and package geometries. The dependencies of the coefficient of variation (essentially the degree of uniformity of the particle distribution) and the failure probability on the volume fraction are examined and the corresponding results are used to derive the correlation between the stochastic error and the coefficient of variation for a given volume fraction. In general, the current results indicate that the effects of systematic errors on the accuracy of the estimated failure probability can be controlled by improving the accuracy with which the resin and conductive particle components of the ACF compound material are weighed during the ACF fabrication process. However, the effects of stochastic errors cannot be controlled and vary as a function of the absolute value of the volume fraction and the degree of non -uniformity of the particle distribution. Nevertheless, the results indicate that the effects of both systematic and stochastic errors can be suppressed by specifying the volume fraction as the value corresponding to the tip of the V-shaped curve when designing the ACF compound.