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Fiber laser fabrication of plastic-metal hybrid joints for medical device applications

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Currently, micro-joining of plastic to metal parts in medical devices is achieved using medical adhesives, e.g. pacemakers, defibrillators, and neurological stimulators are designed using silicone adhesive to seal the joint between polyurethane connector module and titanium. Nevertheless, the use of adhesive is problematic because it requires a long time to cure and has high tendency to produce leachable products. An alternative for direct joining of plastic to metal without adhesive is therefore required. Laser transmission joining (LTJ) is growing in importance and has high potential to gain the niche in micro-fabrication of plastic-metal hybrid joints for medical device applications. The widely-accepted understanding of LTJ between plastic and metal is that generation and rapid expansion of micro-bubbles at the plastic-metal interface exert high local pressure to press the melted plastic towards the metal surface features during laser processing. This subsequently creates the plastic-metal hybrid joint by mechanisms of mechanical interlocking, chemical and physical bonds between the plastic and metal surfaces. Although micro-bubbles can help promote the mechanical interlocking effect to increase the joint strength, creation of bubble is a random and complex process depending on the complicated interactions between laser intensity, thermal degradation properties of plastic, surface temperature and topographical features of metal. In ideal situation, it is desirable to create the plastic-metal hybrid joint without bubbles. However, the mechanical performance of hybrid joint without bubbles is still unknown. Systematic comparison between the hybrid joints with and without bubbles is lacking in literature. This became the objective of this study.

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Three-step-concept (TSC): Boltzmann-Arrhenius-Zhurkov (BAZ) physics-of-failure equation sandwiched between two statistical models, with application to aerospace optics reliability

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When encountering a particular reliability problem at the design, fabrication, testing, or an operation stage of an aerospace optoelectronics product's life, and considering the use of predictive modeling to assess the seriousness and the likely consequences of the a detected failure, one has to choose whether a statistical, or a physics-of-failure-based, or a suitable combination of these two major modeling tools should be employed to address the problem of interest and to decide on how to proceed. A three-step concept (TSC) is suggested as a possible way to go in such a situation. The classical statistical Bayes formula can be used at the first step as a technical diagnostics tool. The recently suggested physics-of-failure-based Boltzmann-Arrhenius-Zhurkov (BAZ) model and particularly its multi-parametric extension can be employed at the second step to assess the remaining useful lifetime (RUL) of the faulty device(s). If the RUL is still long enough, no action might be needed, but if it is not, corrective restoration action becomes necessary. In any event, after the first two steps are carried out, the device is put back into operation (testing), provided that the assessed probability of its continuing failure-free operation is found to be satisfactory. If an operational failure nonetheless occurs, the third step should be undertaken to update reliability. Statistical beta-distribution, in which the probability of failure is treated as a random variable, is suggested to be used at this step. The suggested concept is illustrated by a numerical example geared to the aerospace optoelectronics in en-route flight mission. With some modifications, it could be employed also in many other reliability physics-related problems. It is concluded that the application of the TSC enables one to improve dramatically the state of the art in the field of the optoelectronic devices and products reliability prediction and assurance.

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