

Design Concepts for Laser-LIGA Systems

Laser-LIGA is a (relatively) low-cost alternative to classic synchrotron-based LIGA, with laser ablation of polymer (typically PMMA, polysulphone etc.) followed by electrodeposition (often Ni or Cu) to make a mould. One should consider :-

- A/ Applications
- B/ Techniques
- C/ Solutions

A/ Laser-LIGA holds considerable promise as just *one* tool in the armoury of the MEMS revolution, started in Germany by companies/groups such as such as MicroParts etc. Other groups such as RAL, IMM & various university research depts. have been very active in demonstrating the possibilities of the technique as a step in the fabrication of a wide range of miniature mechanical and electrical parts, with potential applications in many fields of science and industry. However Laser-LIGA as a replication technique is just a special case of laser micromachining, which can also be used as a direct manufacturing tool ; the reality today is that most contract manufacturing of microparts uses direct laser micro-micromachining, with 80% of those applications being in the medical device area.

B/ The requirements of a Laser-LIGA excimer machine are just those of a flexible & multi-functioned excimer-based micromachining centre. As in micromachining, Laser-LIGA can be performed using sequential or parallel processing ; an ideal installation should be capable of both, rapid production using parallel or multiple processing, customization/repair using sequential processing:-

Sequential :- projection of ONE of a range of simple motifs, combining motif selection, laser firing & part motion, to produce complex structures determined essentially by software. The process typically uses demag. in the range 5-20X. Sequential processing of small motifs rarely requires beam homogenization ; laser repetition rate is at a higher premium than energy.

Multiple :- the beam is split into several smaller beamlets, for parallel processing of several parts as above.

Parallel :- projection of the image of a complex mask. Process area is mainly limited by required e.d. to the order of 10mm², though this may be in the form of a strip, larger areas can be processed by mask scanning. Areas exceeding the useful field of the process lens can be treated using Opposed Coordinate Motion (OCM), sometimes with several different complex motifs on a single mask plate. In parallel processing demag. is typically <5, beam homogenization is a must.

A complex mask may also be repetition of a simple motif, to form an array, whilst 3D structures can be created by mask dragging techniques or grey scale masks which are becoming available.

A factor which is of specific interest in Laser-LIGA is aspect ratio, which is an integral function of illumination n.a. and energy density on the part. An facility which has partly experimental/development nature can benefit from an open system architecture which allows reconfiguration to modify key parameters at will, whilst at the same time being retaining industrial-grade reliability.

- C/ Some machines are designed to perform a single task superlatively well, but have low flexibility and reconfiguration possibilities. On the other hand, a machine designed to do everything will probably do nothing well ; the system architect's job is to find the optimum compromise for each installation.
- STRUCTURE - Any precision optomechanical system should be built on a solid and vibration-resistant structure ; Optec uses both natural Impala and synthetic granite bases, set into an adequate support frame. The function of the structure is to define the geometrical relation between mask, lens and part ; relative stability of the laser source & illumination optics is much less critical, though good pointing stability of the source is an important feature.
 - POSITIONING – Final part accuracy is only as good as the part positioning. For a general purpose laser LIGA station we propose 300x600mm travel stages with linear motor drive ; these low mass high stiffness stages have 0.25 μ m resolution, <0.5 μ m repeatability and overall unmapped position accuracy of 15 μ m(DMC also available). 360° rotation stage is rarely required for excimer machining, whilst the added height reduces X,Y accuracy because of pitch/roll/yaw. Better is a flat theta trim stage(ADJ-160) which allows full manual part rotation, with high resolution motor drive over +/-3°, used for automatic alignment of parts w.r.t. pre-existing features or marker fiducials.
 - LASER SOURCE – Optec generally proposes GSIL IPEX, 80W laser, with excellent industrial record, good service access, and competitive price. However, Optec is an independent manufacturer, and we have also installed systems based on alternative sources, where these are preferred by the end-customer. All excimer lasers can be relatively easily switched from KrF to ArF operation. Machining is always a little bit more precise at 193nm and a few materials can only be machined at this wavelength ; 248nm offers the advantages of higher energy, better gas fill lifetime and improved cavity/optics lifetime. Optec can also offer dual wavelength BDU, or even dual laser system.
 - BEAM DELIVERY - is always divided into illumination & imaging sections, using both commercially available components and special in-house designs(which are also sold as BDU components to other system builders). Optec can propose dual BDU design :-
 - a) Fixed demag. parallel processing with mask scanning or OCM(depending on target part sizes), beam homogenization etc.
 - b) Sequential processing using Optec confocal lens, with multiple motif selector and choice of demag.
 - VISION - through the lens(TTL) vision is essential for sequential processing, aligning parts, focussing, process monitoring etc. It is not so essential for OCM processing.
 - CONTROL – all Optec machines use ProcessPower, our in-house software which offers flexible control of all axes including laser, plus numerous handy routines. In addition, we provide a customized software interface to suit individual requirements.