Picosecond Laser Welding of Dissimilar Materials

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1. Motivation
Many modern devices require direct dissimilar material joining.
Standard techniques rely on frit, solder or adhesive interlayers
- Interlayer curing can give imprecise positional placement
- These interlayers often give poor aging properties
- Creep, outgassing etc.
A direct bonding technique is preferred.
Differences in material (thermal) properties makes traditional welding impracticable.

2. Process
A Trumpf Tru Micro (400kHz, 1030nm, 5.9ps) laser is focussed to a small (1.2µm) spot.

Two materials (one transparent at 1030nm) are held contact with a clamp.
Point loading ensures optical contact at start of weld.
Stages translate the focal volume through the material interface.

3. Glass - Glass welding
As a preliminary step investigations of glass-glass (similar material) welding was carried out.

A spiral pattern was initially used to “draw” optical contact and reduce stress.
Optical contact is maintained over and around weld area.

Systematic investigation of weld area and strength is still being carried out, however indications of:
- Welded line width is linearly dependant on power
- Potential optimal weld power between non-welding and cracking of bulk material
Weld break tests show breakage around welded volume.
This suggests the creation of a weak glass area around the weld through densification.

4. Dissimilar Materials - Proof of principle
Setup unchanged from glass-glass system.
Opaque material must, in general, be carefully polished to gain optical contact.
Linear-rather than nonlinear-absorption drives the process.
Material flatness appears more important than smoothness.

5. Material smoothness and roughness
Proof of principle experiments demonstrated smoothness less important than flatness.
Experiments carried out with rough samples to determine limits.

Rough Al (above) sample demonstrated to partially weld to fused silica.
Material roughness and flatness requirements are consistent with high speed steel milling.

6. Weld strength and reliability
High degree of irregularity seen in weld strength which is dependant on:
- Surface flatness
- Accuracy of focal depth
- Weld geometry
- Generates local stress issues
Alternative “spot” geometry may improve reliability by limiting crack propagation.

Grid pattern has been demonstrated to allow crack free (or reduced) welding in stainless steel.
Pattern is highly scalable for large areas.

7. Cross-sectional analysis
Polished cross-section of Al-silica weld shows larger weld volume in glass than metal.

This is consistent with a “two step” weld visible with dark field microscopy (right).

Analysis with XPS shows true mixture of aluminium and silica in weld.

6. Conclusions
We have demonstrated a capability to weld dissimilar (metal-glass) materials using a ps laser system.
Successful welding is dependant on maintaining optical contact.
- Requires flat smooth samples
- Compatible with milled surfaces
Further work:
- Increase weld areas and demonstrate welding of bulk materials.
- Increase reliability of welding system through pre-weld surface treatment.
- Welding of dissimilar non-metallic materials.
- Analysis of weld geometry and absolute weld strength.

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