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Laser welding of crystalline sapphire for future gravitational wave detectors

With many next-generation gravitational wave detectors planning to implement crystalline materials as replacements for fused silica, there is an increasing need for novel techniques in suspension jointing. In current aLIGO systems, fused silica fibres are laser welded to the test mass ears, achieving low thermal noise levels. This project focuses on developing and characterising a laser welding technique for crystalline sapphire. Utilising a CO_2 laser within a crystal growth machine, specifically designed for laser-heated pedestal growth, we established a repeatable method for laser welding sapphire rods of varying millimetre diameters. Experimental characterisation of tensile strength, thermal conductivity, crystallography, and mechanical loss revealed promising results that support the feasibility of this technique. Additionally, we demonstrated a laser polishing method that greatly enhanced tensile strengths to over 1 GPa. These initial findings indicate significant potential for sapphire welding as a viable concept in next-generation cryogenic detector suspensions and provide strong justification for further development of this jointing method.

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