

Methods of Improving Optical Contacting

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Abstract

Through optical contacting, two silicon objects can be bonded strongly and closely enough to turn them into a single object with the same thermal properties. By investigating the conditions under which this bond is optimized, silicon optical contacting could be a solution to conjoining pieces of high precision equipment in space.

Background

Optical contacting is the phenomenon of bonding very flat, highly polished surfaces together using molecular forces instead of adhesives. Van der Waals dispersion forces are believed to be the main cause of this adhesion. These forces are weak between single atoms and molecules at large distances, but bring many atoms and molecules very close together and it makes for an incredibly strong bond. Any contamination or deviation from flatness will result in fewer, weaker bonds, hence polishing and cleaning are an imperative step in optically contacting two plates.¹

When performed properly, the bond between the two surfaces is strong enough to effectively turn them into one plate. The applied force is concentrated at the edge, so while pulling apart the two objects plates is difficult, it can be broken by wedging the plates apart at an edge or corner.² The only way to destroy this adhesion is through thermal stress, where unequal heating causes thermal expansion to break the closeness of the surfaces.³ The efficacy of the bond can be tested by determining the tensile strength or measuring heat flow.^{1,4}

Heat and pressure were shown to be important in creating a good bond.⁴ Optical contacting could theoretically occur between any two surfaces, but it is typically performed with silicon or silicon-containing molecules due to its weight and thermal properties.

Motivation

Optical contacting is a fairly unexplored field but has big uses in space, where strong, light bonds are a necessity. Furthermore, the near perfect bond allows two pieces to effectively

be turned into one without the use of adhesives which risk failing due to having different chemical and thermal properties. Silicon's small thermal expansion coefficient makes it particularly useful for high sensitivity probes¹ including gravitational wave detectors such as LISA and the LIGO Voyager.

However, before optical contacting can be of use, it needs to be studied further. The aim of my research is to explore methods of optimizing optical contacting to produce a consistently strong bond. This includes refining previous work which indicated that heat and pressure were instrumental in good bonds. If I can produce sufficiently strong bonds, I will proceed to working on their application in the LIGO Voyager.

Approach

I will create smooth silicon surface then optically bond it in a sterile environment. Once a bond has been achieved, I will test the strength then repeat the process based on the gained insights.

Proposed Work

Week 1 – 2: Training and familiarization with fabrication and preparation of silicon surfaces.

Week 3 – 4: Attempting to achieve optical contact.

Week 5 – 6: Testing different bond methods, including controlling heat and pressure.

Week 7 – 10: Measuring the success of bonds and further refining methods to improve their strength.

Summary

Through optical contacting, silicon surfaces can be adhered into a single object which, if optimized, could prove useful for the LIGO Voyager.

References

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