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NASA TECH BRIEF

Goddard Space Flight Center

Eutectic Bonding of Sapphire to Sapphire

The problem:

The bonding of sapphire to sapphire for production of sapphire rubidium maser cells involves certain difficulties. First, because sapphire has a very narrow temperature range (one degree Kelvin) between its solid and liquid states, direct bonding is impractical. Second, bonding of sapphire at elevated temperatures by use of metalizers and brazing or by use of graded glass sealing increases the possibility of contamination because rubidium vapor reacts with metals and glass at high temperatures.

The solution:

A eutectic mixture of aluminum oxide and zirconium oxide provides a new bonding technique for sapphires and rubies. The technique effectively reduces the possibility of contamination.

How it's done:

The bonding material is an aluminum oxide and zirconium oxide mixture that matches the coefficient of thermal expansion of sapphire. In general, the proportion of aluminum oxide in the mixture varies from about 85 to 35 mole percent and that of zirconium oxide from 15 to 65 mole percent, respectively. The optimum mixture of Al_2O_3 to ZrO_2 is 75 to 25 mole percent, respectively. The bonding temperature depends on the particular mixture and varies anywhere from 2173 to 2273 K with approximately 2248 K being the optimum.

To insure homogeneity in the eutectic mixture, these oxide powders must have a relatively fine powder size. A 300 mesh or finer grain is generally acceptable, with the optimum size being approximately 325 mesh.

The bonding technique first requires mixing the Al_2O_3 and ZrO_2 into a slurry with distilled water. This mixture is then painted on the sapphire surfaces to be bonded. The surfaces are then placed together, and the entire assembly is put into a high-temperature furnace and fired in air, inert gas, or vacuum for about two hours. Temperature in the furnace during firing is above the eutectic temperature of sapphire, but below its melting point. After firing, the temperature in the furnace is dropped to the eutectic level for about half an hour. The assembly is then cooled to ambient temperature for about four hours. After cooling, the bonded assembly can withstand temperature cycling up to 2073 K.

As an alternate, it is also possible to form the eutectic mixture in situ by depositing a layer of zirconium oxide on the sapphire surfaces by electron beam vacuum deposition. The sapphire surfaces are then assembled and bonded as described previously.

Note:

Requests for further information may be directed to:

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Reference: TSP73-10284

Patent status:

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

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