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Author: Mr. Aman Bhavsar
Vellore Institute of Technology, India

Mr. Sahil Parmar
University of Southern California, United States

DEVELOPMENT OF ECONOMICALLY FEASIBLE MICROGRAVITY DIAMOND MANUFACTURING TECHNOLOGY FOR SPACE COMMERCIALIZATION

Abstract

The space industry, a longstanding driver of technological advancement, is poised for a revolutionary leap with the commercialization of diamond manufacturing in microgravity. While space endeavors have traditionally served humanity through satellites and communication, leveraging microgravity presents a new avenue for sustained economic growth. Current ventures, largely centered around human spaceflight, offer limited monetary returns. However, capitalizing on microgravity's unique conditions unlocks diverse opportunities. Microgravity's controlled convection and absence of sedimentation enable unparalleled material control, fostering the growth of larger, superior-quality crystals. The ultraclean vacuum in space facilitates the creation of pristine, defect-free materials through vapor deposition. Liquids in microgravity naturally form perfect spheres, advantageous for various applications requiring uniform spheres of consistent size. Additionally, the extreme heat and cold available in space can be harnessed to produce robust, glassy materials. This paper explores the utilization of ultraclean vacuum conditions and enhanced crystal growth to employ the Chemical Vapor Deposition (CVD) Chrome method for diamond manufacturing in space. Building upon prior successes like the synthesis of diamond thin-film in microgravity through the Japanese free-flyer program, this research aims to detail the process. Beginning with a minute diamond seed, CVD employs ultra-pure carbon-rich gases in a controlled environment. Within three to four weeks, significant crystals—typically three to five carats in size—are cultivated. These Type IIa diamonds, exceedingly rare in nature due to their minimal impurities, represent the pinnacle of purity and quality. The paper focuses on the technical intricacies and proposes a feasible setup for manufacturing diamonds in microgravity. Additionally, it provides an economic analysis of introducing this concept to the space industry, highlighting its potential as a lucrative venture. By marrying technological innovation with economic viability, this endeavor heralds a transformative era in space commercialization.