# Bottom-Up approach for synthesis of structured diamond films

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The discovery of how to make synthetic diamonds, as well as their associated 0D, 1D, 2D, and 3D defects, and unique optical, electrical, thermal, chemical, and mechanical properties, has piqued curiosity. Many applications today call for structured diamond arrays, but diamond's hardness and chemical resistance make it challenging to etch and design in top-down approach. Using viewpoints from physics and material science, this research intends to introduce an approach that leverages bottom-up diamond film manufacturing by plasma-enhanced chemical vapor deposition (PECVD) with controlled nucleation sites.

The study used controlled seeding through the masking of seeded Si substrate to prevent diamond growth in the areas covered by mask. Prepared substrates with masks were then used to synthesize diamond films by PECVD technique. Masks made of Au, Cu, $SiO_2$, $TiO_2$, and Cr were applied using combination of electron beam lithography and physical vapor deposition methods. PECVD processes were performed at substrate temperature of 720–960 °C and pressure of 98 mbar. Deposited diamond films contained nano-crystalline diamonds, single-crystal diamond needles, and polycrystalline diamond films with diamond phases composing cubic <100>, octahedral <111>, cubo-octahedral (consisting of both <100> and <111> oriented crystals), and twinned faceted faces. The composition and surface morphology of the crystals were studied using scanning electron microscopy and Raman spectroscopy.

The quality of the five diamond suppressing masks deposited by physical vapor deposition was evaluated using scanning electron microscopy, and $SiO_2$, $TiO_2$, and Cr masks performed admirably. Synthesized diamond films were optically examined with Raman and photoluminescence spectroscopies at room temperature and revealed NV color centers with narrow zero phonon lines centered at roughly 575 nm (neutral NV centers). The proposed approach is perspective for quantum technological applications due to the successful structuring of diamond films.

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