

Enhanced diamond nucleation on copper substrates by employing an electrostatic self-assembly seeding process with modified nanodiamond particles

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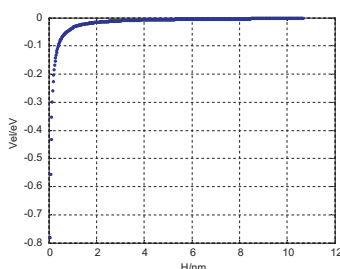
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HIGHLIGHTS

- ▶ Surface modification and fraction-alization prepared a nanodiamond colloid.
- ▶ Two-dimensional self-assemblies of nanodiamond seeding without any contaminations.
- ▶ The seeding process was revealed from the nonlinear Poisson–Boltzmann theory.
- ▶ The interaction energies between ND particle and Cu substrate were calculated.
- ▶ High quality of 800 nm thick continuous diamond film was deposited in 60 min.

GRAPHICAL ABSTRACT

By adopting the nonlinear Poisson–Boltzmann theory, the electrostatic energy in the seeding process was calculated, where $a_2 = 25.3$ nm, and the measured zeta potentials of $\xi_1 = -41.5$ mV, $\xi_2 = 70.7$ mV for nanodiamond particles and copper substrate, respectively, at pH 6.7, are used in the analysis. As the curve shown, when the distance between nanodiamond particles and copper substrate decreases, the value of the electrostatic energy exponentially increases.



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ABSTRACT

Nanodiamond seeding is a well-established approach to enhancing the nucleation density in chemical vapor deposition (CVD) diamond growth. However, the effects of nanodiamond seeding are highly dependent upon the dispersion properties of nanodiamond particles, the solvent and the interaction between nanoparticles and substrate surfaces. Surface modification and fractionalization were employed to improve the dispersion of nanodiamond particles and separate those particles into a more narrow range of particle size. Mono-dispersed nanodiamonds with a ζ -potential and average particle size of -41.5 mV and ~ 25.3 nm, respectively, were then obtained. They can be charged on copper substrate without any contaminations. Two-dimensional self-assemblies of nanodiamond seeding were actualized. The density and homogeneity of nanodiamond particles which act as pre-existing sp^3 seeds shorten the incubation time of diamond nucleation to less than 30 min. High quality of 750 nm thick continuous diamond film was deposited on copper substrate in 60 min. Furthermore, we calculated electrostatic interaction energy between nanodiamond particle and copper substrate by using the nonlinear Poisson–Boltzmann theory, and discussed interaction energy of nanodiamond–Cu substrate and nanodiamond–nanodiamond in the seeding process.

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1. Introduction

CVD diamond deposition on non-diamond substrates requires surface treatment in order to achieve a high nucleation density [1]. One of the most widely used approaches is seeding the substrate with diamond particles dispersed in an appropriate solvent

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