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Physical vapor deposition (PVD) has greatly matured in terms of growth modeling and equipment available. For this reason, and the often-required limitation to low-temperature processing, it is appealing to utilize PVD methods not only for thin films but also for the synthesis of nanostructures. This is true even as many other methods enjoy the advantage of not needing high vacuum equipment.

PVD techniques are traditionally classified by the method of vapor generation, though here it is argued that a physically meaningful classification can be based on the energetics of film-forming species. At the low end of the energy scale, evaporation methods can be used to produce columnar structures with significant porosity. Sputtering at high pressure results in similar properties. This regime is preferred for sculptured structures, which involves moving tilted substrates (chiral films, chevrons, etc. [1]). As the energy is increased, so is the mobility of surface atoms, and we enter an energy regime that is widely used in thin film deposition by magnetron sputtering. Recently, high power pulsed sputtering has evolved as an energetic extension of conventional sputtering [2]. The enhanced degree of ionization enables the efficient application of bias techniques. Additionally, species seem to have higher kinetic energy. Ultimately, one would like to have fully ionized plasmas to fully exploit biasing, which can be done by using filtered cathodic arc plasmas [3]. Considering the high-energy range, substrates can be ion-treated by immersing them in a plasma and applying high voltage pulses, a technique known as plasma-based ion implantation.

Nanostructures are preferentially fabricated at either the low energy (< 1 eV, e.g. for sculptured films) or very high energy (> 1 keV, e.g. metal filling of lithographically produced nanotrenches [4], or formation of precipitates or bubbles by ion implantation [5]). At the intermediate energy range, ~ 100 eV, nanoscale processing of interfaces is used to obtain coatings with superior adhesion. Subplantation growth is facilitated at this energy, which is especially important for tuning the structure and properties of diamond-like carbon and a range of nitride and oxide materials.

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