Design of Novel Nanocrystalline Composite Materials by Means of Plasma CVD

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The properties of many materials undergo significant changes when the crystallite size reaches the range of nanometers. Because of their technological applications, such "**nanocrystalline materials**" are receiving increasing attention, and in some cases, are already being used in industrial products (e.g. high density magnetic memories). In this paper we shall briefly discuss two examples from our recent work.

Silicon dominates the microelectronics but, because of its indirect band gap, it cannot be used in optoelectronic devices such as light emitting diodes and others. However, as it has been shown recently, porous silicon (prepared by anodic etching of Si-wafers in an HF/ethanol/water solution) with a crystallite size of few nanometers shows an efficient photoluminescence. The disadvantages of porous silicon are its brittleness, high porosity and a relatively poor control of the crystallite size. Therefore our work concentrates on the preparation of compact films of **nanocrystalline light emitting silicon** by plasma CVD and posttreatment (oxidation of the grain boundaries and annealing in forming gas). The plasma CVD technique allow us to exactly control the crystallite size and the thickness of the grain boundaries which determine the efficiency of the photoluminescence. Moreover, the technique is compatible with the silicon technology. The preparation procedure will be outlined together with some optoelectronic properties of the nc-Si films.

The strength of materials is determined by the movement of dislocations and, therefore, it is orders of magnitude smaller than the theoretical value for a perfect crystal. The precipitation hardening is based on the pinning of dislocations within the grain boundaries of microcrystalline materials where the strength increases with the decreasing crystallite size according to the Petch rule. A further increase of the strength is achieved in nanometer thin epitaxial heterostructures consisting of a suitable combination of metals which avoids the movement of the dislocations through the interface. The concept of our **novel superhard nanocrystalline composites** is based on a similar principle but, unlike the heterostructures which are difficult to prepare, it offers a series of possible materials for practical applications. We shall present results on the preparation and characterization of thine films with a hardness of ≥ 4000 Vickers and a high elastic modulus. Plasma CVD allows us to control the crystallite size within the desirable range of 1 to 3 nm and the amorphous matrix in which the crystallites are imbedded. Data will be presented to demonstrate the effect of the crystallite size on the properties of the material. The possibilities to cover a larger range of different materials for various applications will be discussed.