Optoelectronic properties of Cr-doped amorphous AlN films

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Some of the most remarkable advances in the field of materials science were based on the achievement of new properties simply by changing the composition and/or the structure of certain pre-existing compounds. In fact, that was the basis of our modern micro-electronics industry where quite different characteristics can be obtained by suitably inserting impurity elements in a semiconductor matrix. More recently, and looking for compounds capable of combining optical-electronic-magnetic properties, many different classes of materials and methods have been systematically investigated. Within them one can mention, for example, the doping of semiconductor or dielectric compounds with rare-earth or transition-metal elements. Motivated by the above ideas, and aiming at the development of new optical-electronic materials, this work reports on the investigation of chromium-doped amorphous aluminum-nitride (a-AlN) thin films.
All a-AlN samples considered in this work were prepared by sputtering an Al target in an atmosphere of pure nitrogen. The doping with Cr was achieved by putting small pieces of chromium metal onto the surface of the Al target. The Cr-to-Al relative area determines the doping concentration, which stayed in the 0.0001–2 at.% in the present investigation. In order to activate the Cr^{3+} optical centers the films were submitted to thermal treatments in the 300–1200 ºC temperature range in an atmosphere of oxygen. The experimental spectroscopic investigation included: energy dispersive x-ray spectrometry, photoluminescence and optical absorption measurements.
The experimental results indicate that both the Cr concentration and the annealing temperature influence the optoelectronic properties of the a-AlN films. When inserted in a nitrogen-rich atomic environment (relatively low annealing temperatures) Cr^{3+} ions exhibit room-temperature light emission at approx. 685 nm. Thermal annealing at high temperatures induces the development of microscopic structures that luminesce at approx. 693 nm– suggesting the presence of ruby (Cr^{3+}-doped Al_2O_3) species embedded in the amorphous AlN matrix. The effect of different atomic environments as well as the optical-electronic mechanisms behind the Cr^{3+}-related light emission will be presented and discussed in view of our experimental data.
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