Characterization of an e-beam deposited ZnS film for high-reflectivity and low-loss coating

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Abstract

In nowadays gravitational waves detectors the limiting noise at mid frequency is due to Brownian thermal noise in the multilayer reflective coating, in particular in the intrinsic dissipation inside the high refractive index material [1]. The anelastic behaviour of amorphous materials is explained by the presence of a number of metastable states. Any two of these states that are separated by an energy barrier is called a Two Level System (TLS)[2]. The number density of TLS can vary a lot from material to material or even within the same material depending on the production technique or treatments used. Not all the TLS contribute to the mechanical losses. The ones that are active are only those with a relaxation time comparable to the period T of the strain wave propagating in the material. In our case the TLSs that contribute to the mechanical losses at room temperature are those that have a barrier height of about 0.5 eV. In order to reduce the loss angle of amorphous materials two basic ideas can be pursued: 1) a reduction of the total number density of TLS; 2) an optimal distribution of TLS. An ideal state "ultra-stable glass" with very low density of accessible TLS might in principle be reached [3]. Depositing amorphous films in which coordination number of their constitutive atoms is superior to 3 should lead to a low number of TLS. Indeed, if an atom is linked with two other atoms, local structural rearrangements can occur whereas if this atom is linked to at least four atoms non on the same plane, the structure is more rigid and TLS are unlikely. The structural units of these high coordinatio number materials are often linked via their edges or their faces making structural reorganization more difficult. We investigated the possibility to use ZnS, deposited by e-beam, as high coordination number material with high refractive index in multistack film for future GW detector mirrors. Morphological, structural and optical characterization of a monolayer film deposited through e-beam will be reported.

References

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