Design of X-Ray Supermirrors

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A new approach is proposed for the design of wide band-pass multilayer optical elements for the hard x-ray spectral region. The method, based on the combination of analytical and numerical methods, solves the inverse problem consisting of inferring the composition profile of a depth-graded multilayer coating. First, assuming the multilayer d-spacing profile to be a monotone function of the depth and the d-spacing gradient to be large enough, we derived the differential equation that describes the change of period necessary to guarantee a given spectral reflectivity profile. Then, a computer code using an algorithm of steepest descent was used to refine numerically the multilayer period profile, each layer thickness being treated as an independent variable. When using the solution to the differential equation as a starting point for the direct problem, a many-fold decrease of computer time could be obtained. At each step, the spectral dependence of reflectivity was accurately computed using a standard matrix method. Simulations of the particular case of constant reflectivity over a wide spectral range are presented. The best choice of material pairs for composing a depth-graded multilayer structure is discussed from the viewpoint of maximum achievable reflectivity and least number of bi-layers. Features of depth-graded multilayer mirrors, which are distinctive from conventional periodic mirrors, are considered.