

## Evolution of Electronic and Magnetic Properties of Magnetite Thin Films by V, Cr, and Mn Substitution

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Variation of electronic and magnetic properties and the related ionic spin configuration in magnetite ( $\text{Fe}_3\text{O}_4$ ) thin films substituted by 3d transition metal (TM) V, Cr, and Mn has been investigated. Cubic structure is maintained for all the cases ( $\text{T}_x\text{Fe}_{3-x}\text{O}_4$ , T = V, Cr, and Mn) for  $x < 1.0$ . The lattice constant increases with increasing Mn substitution while it decreases for Cr substitution. The ionic valence of V, Cr, and Mn are estimated by analyzing X-ray photoelectron spectroscopy and Mössbauer spectroscopy. Change of the electronic structure by TM substitution can be figured out using optical absorption data measured by spectroscopic ellipsometry. The saturation magnetization ( $M_s$ ) measured by vibrating sample magnetometry (VSM) also varies with dopant species and density. The increase of  $M_s$  at low V and Cr density can be explained in terms of spin-flip of octahedral  $\text{Fe}^{2+}$  ions.