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Thickness dependent wetting properties of thin films of ceramics based on low-electronegativity metals

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We have previously shown [Zenkin, S., Kos, Š., Musil, J. (2014), Journal of the American Ceramic Society, 97: 2713–2717] that oxides and nitrides of low-electronegativity metals form intrinsically hydrophobic hard ceramics needed for various harsh-environment applications. The van Oss-Good-Chaudhury approach based on the Lifshitz-van der Waals/acid-base theory used for the analysis of the results revealed that the dominant component of the surface free energy of these ceramics is the electrostatic Lifshitz-van der Waals component, strongly suggesting a thickness dependence of the wetting properties. We used the reactive high power impulse magnetron sputtering with a pulsed reactive gas flow control as a novel technique capable of producing dense films with smooth surfaces and well controlled thickness down to units of nm. We prepared films of HfO_2 as a typical case of a low-electronegativity-metal based ceramic. We have found a thickness dependence of the water droplet contact angle ranging from 120º for the thickness of 50nm to 100º for the thickness of 2300nm considered as bulk material. The Lifshitz-van der Waals component of the surface free energy remained the dominant component throughout the range of measurement and exhibited a corresponding thickness dependence. The XRD and FTIR showed only minor differences among the films. We propose two explanations for the observed thickness dependence of the wetting properties: influence of the sub-dominant texture and/or non-monotonic size dependence of the crystal grain surface energy.

Keywords
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hydrophobicity
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