Undoped and doped vanadium dioxide: synthesis, characterization and applications

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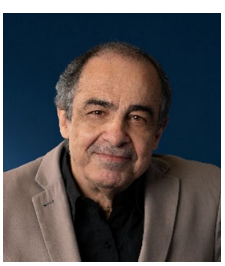
Abstract

Vanadium dioxide (VO_2) is a "smart" material that exhibits a first-order reversible metal-to-insulator transition (MIT) at a T_{MIT} temperature of ≈ 68 °C in response to external stimuli, such as temperature, electric fields and optical signals. This transition is accompanied by a dramatic variation of electrical resistivity and reflectivity in the infrared and THz domains. In a recent work, our group has investigated how novel dopant elements like B [1] can be incorporated into high-quality VO_2 thin films via pulsed laser deposition (PLD) in order to tune its temperature-dependent metal-insulator phase transition. Extensive characterization of the doped materials allowed us to elucidate the interplay between doping and phase stabilities based on their electrical, structural, and morphological properties. In addition, we were able to develop an innovative method to deposit high-quality VO_2 thin films at low temperature on a large area scale, which is highly advantageous for thermochromic coatings and/or deposition on heat-sensitive flexible polymer substrates [2]. The effect of both strain and doping was also explored to understand how interfaces can affect the VO_2 phase transition properties [3]. Substrates were found to influence the crystal and microstructure via strain, which impacts the potential use of VO_2 in various applications, Lastly, we began to utilize first-principles calculations to understand and predict the VO_2 phase transition property changes on a sub-atomic level to facilitate rational material design [4,5].

Recent Publications

1. Hajlaoui, T.; Émond, N.; Quirouette, C.; Le Drogoff, B.; Margot, J.; Chaker, M. Metal–insulator transition temperature of boron-doped VO2 thin films grown by reactive pulsed laser deposition. Scripta Mater. 2020, 177, 32-37.
2. Xiang, W.; Le Drogoff, B.; Chaker, M. An innovative method to achieve large-scale high-quality VO2 thin films: Oxidation of vanadium nitride material deposited by sputtering. Appl. Surf. Sci. 2023, 633, 157607.
3. Chaillou, J.; Chen, Y.-F.; Émond, N.; Hajlaoui, T.; Torriss, B.; Malviya, K.D.; Orgiu, E.; Chaker, M. Combined Role of Substrate and Doping on the Semiconductor-to-Metal Transition of VO2 Thin Films. ACS Appl. Electron. Mater. 2022, 4, 1841-1851.
4. Koch, D.; Chaker, M. The Origin of the Thermochromic Property Changes in Doped Vanadium Dioxide. ACS Appl. Mater. Interfaces 2022, 14, 23928-23943.
5. Koch, D.; Chaker, M. Chalcogen Doping as a Promising Strategy to Improve the Thermochromic Properties of Vanadium Dioxide. J. Phys. Chem. C 2023, 128,

Biography



Mohamed Chaker has been a professor at the Institut National de la Recherche Scientifique (INRS) in Varennes, Quebec, Canada since 1989. Holding a Tier 1 Canada Research Chair in Plasmas applied to micro and nanomanufacturing technologies since 2003, he has published over 340 articles in peer-review journals (17500 citations, H-index=72 according to Google Scholar) in various domains, including advanced plasma sources characterization (high-density plasmas and laser-induced plasmas) for applications to thin film and nanomaterials synthesis, nanometer pattern transfer and device fabrication. From 1999 to 2002, he has been the director of the Center Energie et Matériaux of INRS, then from 2002 to 2005, the director of the Center Énergie Matériaux Télécommunications. He played a leadership role in the development of Quebec consortia (Prompt-Québec, NanoQuébec). From 2005, he is the director of the Laboratory of Micro and Nanofabrication (LMN) of INRS.

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