In this work, electro-thermo-optical devices were developed for near-infrared (NIR) wavelengths by exploiting the optical properties of vanadium dioxide (VO$_2$). VO$_2$ undergoes into an insulator-to-metal transition (IMT) in which its optical, electrical, and structural properties change abruptly as a function of its temperature. The changes in these properties show hysteretic behavior.

Sol-gel deposition process was investigated for growing VO$_2$ thin films on SiO$_2$ and SiO$_2$/Si substrates. Its composition and crystallization were characterized by X-ray diffraction and Raman spectroscopy. Atomic force microscopy and a 3-D surface contact profilometer were used to analyze the surface topography of the films. These thin films were compared with VO$_2$ thin films deposited by pulsed laser deposited (PLD). VO$_2$ thin films deposited by PLD were used to develop the devices presented in this work.
In the present work, the IMT is induced thermally, using photo- or electro-thermal techniques. Two devices were developed: 1. a NIR image projector and 2. a fully electronic variable optical attenuator (VOA) to operate in the NIR region. The first device uses the inherent hysteresis in the optical properties of VO$_2$ across its phase transition, which allowed for the programming of patterns onto the VO$_2$ thin film. The second device emerged from the optical transition in VO$_2$, in which the electro-optical changes in the film were induced electro-thermally (i.e. a “thermo-electro-optical device”). The strong correlation between the electrical and optical properties in VO$_2$ enabled the implementation of a self-sensing technique, which reduced the optical hysteretic behavior and simplified the modeling and control of the attenuation.

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