Non-Volatile, Tunable Infrared Camouflage Using Rosaceae Plant-Inspired Multispectral Design

To address this issue, we develop a tunable multispectral compatible infrared camouflage device using phase change material In3SbTe2 (IST).

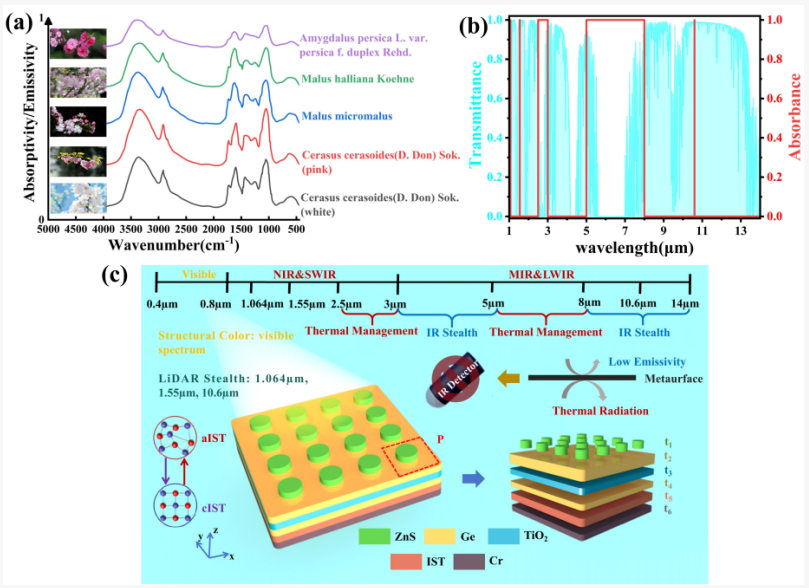

Fig. 1 (a)The infrared emissivity curve of Rosaceae plants. (b) Atmospheric window transmission spectrum and ideal device spectrum. (c) Schematic diagram of the multispectral compatible infrared camouflage device.

CHENGDU, SICHUAN, CHINA, August 6, 2025 /EINPresswire.com/ -- With the rapid development of multispectral detection technology, the demand for multi-band, multifunctional, and compatible infrared camouflage in complex military environments is becoming increasingly urgent. Traditional infrared camouflage technology mainly focuses on the control of single-band emissivity, and the static design is hard to match with the surrounding environment and actual needs. When the target has a significant difference in emissivity compared to the environment, low-emissivity camouflage may expose itself due to abnormal thermal signals. At the same time, existing technologies often overlook the needs of multispectral compatibility, such as the lack of comprehensive management of heat accumulation, laser stealth, and visible light camouflage when achieving infrared camouflage. The adaptability mechanisms in nature provide new insights, such as the unique spectral characteristics of Rosaceae plants. Their band response patterns offer significant inspiration for the design of tunable and compatible visible light camouflage, as well as infrared and laser stealth. The emergence and application of phase change materials provide a possibility to solve this key problem. The reversible switching between crystalline and amorphous states supports the regulation of optical parameters, enabling multifunctional compatible stealth and camouflage in infrared, laser and visible light bands.

The research and design of an adjustable multispectral compatible infrared camouflage device

based on the infrared radiation characteristics of Rosaceae plants, aims to achieve multifunctional compatibility of infrared camouflage, thermal management, laser stealth, and visible light camouflage. The device design employs a particle swarm optimization algorithm combined with the finite difference time domain method to obtain structural parameters: Cr/In3SbTe2(IST)/Ge/TiO2/Ge/ZnS (top cylindrical). Through experimental verification, it is demonstrated that in the amorphous state (aIST), the device can achieve simulated plant infrared camouflage with emissivities of 0.38 and 0.29 in the 3-5μm and 8-14μm bands, respectively. At the same time, it achieves laser stealth with absorption rates of 0.99, 0.92, and 0.88 at wavelengths of 1.064μm, 1.55 μm, and 10.6 μm, respectively. In the crystalline state (cIST), the device has emissivities of 0.36 and 0.08 in the 3-5μm and 8-14μm bands, respectively, enabling simulated plant infrared camouflage and ultra-low emissivity infrared stealth. At the same time, two non-atmospheric window bands (2.5-3μm and 5-8μm) are used as heat dissipation windows, with emissivity values of 0.62 and 0.55 respectively. Absorption rates of 0.96 at 1.064μm and 0.74 at 1.55 μm can achieve laser stealth. Changing the structural parameters of the top layer can cause color variations, without affecting infrared performance.

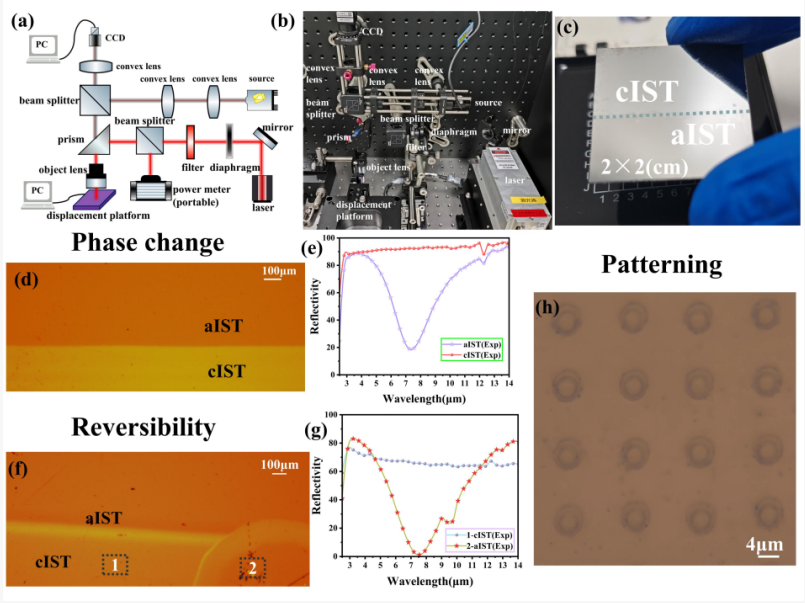

Fig. 2 (a) Schematic Diagram of the Laser Experimental Platform. (b) Constructed Laser Experimental Platform. (c) Schematic diagram of Cr/IST film phase change experiment (aIST to cIST). (d) Cr/IST/SiO2 film phase change experimental (aIST to cIST) optical image.

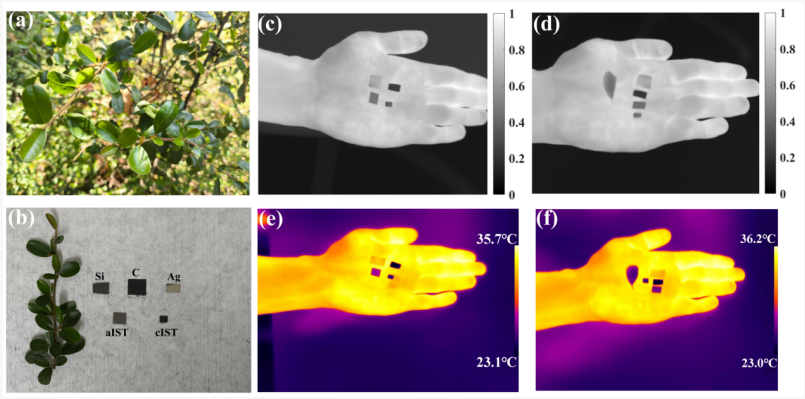

Fig. 3 (a) Rosaceae-Pyracantha fortuneana (Maxim.) leaves. (b) Pyracantha fortuneana (Maxim.) leaves, Si wafer, C powder sheet, Ag film, aIST sample and cIST sample. 3-5 μm infrared camouflage performance: (c) C powder sheet (top left), Ag film (top right),aIST sample.

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Figure 1. demonstrates the design of a tunable multispectral compatible infrared camouflage device based on the infrared radiation characteristics of Rosaceae plants and the ideal device spectrum as a reference.

Figure 2. demonstrates the laser experiment platform to complete the phase change, reversible and patterning experiments on the phase change material IST. Where the SiO2 film is prevented from evaporating gasification of IST during the reversible experiment. Before and after the phase transition, the transformation of the sample from matte color (amorphous state) to metallic luster (crystalline state) can be clearly observed.

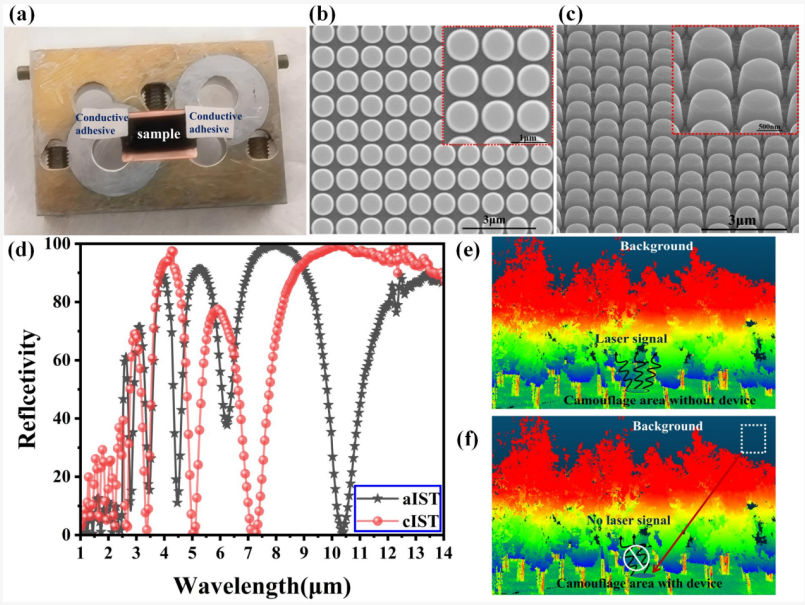

Fig. 4 (a) Schematic diagram of the sample to be etched. (b) SEM top view of the device. (c) SEM 52°(angle with horizontal) side view of the device. (d) Infrared reflectivity spectra of the device in the aIST & cIST states. (e) The forest three-dimensional point cloud.

Figure 3. demonstrates the infrared performance of the device in the 3–5 μm and 8–14 μm ranges, using leaves, a silicon wafer, a carbon powder sheet, and a silver film as comparison samples. The closer the sample emissivity, the more similar the colour in the infrared image.

Figure 4. demonstrates the microform and reflection spectra of the device while simulating the laser stealth effect.

The Micro-Nano Optoelectronics and Intelligent Sensing Research Group is affiliated with the School of Science, National University of Defense Technology. The research directions include: multi-band stealth camouflage and deception, spectral detection and target recognition, optoelectronic information processing, design and integration of micro-nano optoelectronic devices and integrated optoelectronic chips, intelligent algorithms, and optoelectronic sensing. Over the years, under the funding of national key research and development programs, National Natural Science Foundation, foundational strengthening projects, and pre-research priorities, the group's related research has won national and military scientific and technological achievement awards. They have also applied for and granted over 70 national invention patents. The group has published over 200 papers in top-tier journals such as Laser & Photonics Reviews, Advanced Optical Materials, ACS Photonics, Nanophotonics, Photonics Research, and Carbon. Their research results have entered the top 1‰ of ESI and have been selected as significant achievements in Chinese optics.

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