Metamaterials, Invisibility Cloaks and the Next Critical Minerals Demand Story

written by Tracy Hughes | September 2, 2026

The invisibility cloak has long belonged to the world of science fiction. Today, however, researchers can engineer materials that redirect light, radar, sound and heat around an object, reducing its visibility to the equipment designed to detect it. The technology remains far from making a person disappear, but the underlying science—known as metamaterials—is already moving into commercially important applications.

Metamaterials are not defined primarily by what they are made from. Their unusual properties come from how their microscopic or nanoscale structures are designed and arranged. These structures can manipulate electromagnetic or acoustic waves in ways that conventional materials cannot, allowing engineers to control how light, radar, radio signals, sound and even vibration move through space.

The first working metamaterial invisibility cloak was demonstrated at Duke University in 2006. It redirected microwaves around a small object, making the object difficult to detect at a specific frequency. The experiment did not produce a Harry Potter-style cloak, but it proved that electromagnetic waves could be deliberately guided around an object and reconstructed on the other side.

The technology's most immediate value is therefore not human invisibility. It is the ability to make antennas flatter, radar systems smaller, optical sensors thinner and defense equipment more difficult to detect.

That commercial transition has already begun. STMicroelectronics (NYSE: STM) reported in 2025 that it had shipped more than 140 million metasurface optics and related FlightSense modules using technology developed by private company Metalenz, Inc. These ultrathin optical surfaces can perform functions traditionally requiring several curved lenses, opening potential applications in smartphones, biometrics, robotics, lidar, automotive sensing and industrial equipment.

In 2026, researchers reported another significant manufacturing breakthrough: the production of visible-light metalenses at a rate of 300 units per second using an automated roll-to-roll nanoimprinting system. The process used a high-index titanium dioxide coating to improve optical performance and achieved costs described as comparable to—or potentially lower than—conventional lenses. If the process can be reproduced at commercial yields, it could remove one of the largest barriers facing the industry.

Defense and communications may offer even larger strategic opportunities. Kymeta Corporation has commercialized low-profile metamaterial satellite antennas that can track satellites electronically without relying on a mechanically rotating dish. Echodyne Corp. produces compact electronically scanned radar for counter-drone defense, perimeter security and autonomous systems, while Lumotive, Inc. is developing semiconductor-based metasurfaces that steer light without moving mirrors.

This is where metamaterials intersect with the critical minerals economy.

A metamaterial is an engineered architecture, while a critical mineral is a strategically important raw material exposed to supply-chain risk. They are not the same thing. However, many advanced metamaterial devices require semiconductor-grade compounds, specialty metals and exceptionally pure materials that may already be vulnerable to geopolitical disruption.

Depending on the application, metamaterials and metasurfaces can incorporate silicon, copper, aluminum, titanium dioxide, gallium arsenide, gallium nitride, germanium, tantalum pentoxide, indium-containing compounds, gold, silver and phase-change materials containing germanium, antimony or tellurium. Rare earth elements can also enter the surrounding system through lasers, magnets, displays, sensors and specialized optical components.

The quantities used in any individual device may be small. Metamaterials are unlikely to create the kind of bulk mineral demand associated with electric vehicle batteries, transmission infrastructure or conventional steelmaking. Their importance is more closely aligned with semiconductors and defense technologies: modest volumes of highly purified and difficult-to-substitute materials supporting exceptionally valuable systems.

Gallium is one of the clearest examples. Gallium-based semiconductors are already essential to high-frequency communications, radar, power electronics and advanced optoelectronics. As metamaterial antennas, reconfigurable surfaces and optical devices become more sophisticated, demand may increasingly concentrate on processed gallium compounds and secure semiconductor manufacturing—not simply raw gallium production.

Germanium is similarly relevant to infrared optics, night vision, sensors and specialized semiconductors. Tantalum pentoxide is being investigated as a high-performance material for ultraviolet and visible metasurfaces, while indium can be used in transparent conductors and electrically tunable optical devices. Antimony and tellurium may become important in reconfigurable metasurfaces that change their optical properties electronically or thermally.

The investment opportunity consequently extends well beyond mining. It includes high-purity refining, specialty chemicals, deposition targets, semiconductor wafers, foundries, nanoimprinting equipment, optical testing, packaging and defense-qualified manufacturing. A company controlling a mineral deposit will not automatically benefit unless that material can enter the required high-purity downstream supply chain.

Few publicly traded companies focus primarily on metamaterials. MetaOptics Ltd. (SGX Catalist: 9MT) develops metalenses, related manufacturing equipment and metalens-enabled products. The company remains at an early commercial stage, generates limited revenue and is not yet profitable.

STMicroelectronics offers more credible commercial validation but much less concentrated exposure. Metasurface Technologies Holdings Ltd. (HKEX: 8637) owns a minority interest in MetaOptics, although its principal business remains precision machining and welding. Large defense contractors, including Lockheed Martin Corporation (NYSE: LMT), RTX Corporation (NYSE: RTX), Northrop Grumman Corporation (NYSE: NOC) and BAE Systems plc (LSE: BA.), may ultimately incorporate metamaterials into radar, communications, sensing and signature-management systems without reporting the resulting revenue separately.

The sector’s development has not been without setbacks. Meta Materials Inc., formerly listed on Nasdaq under the symbol MMAT, entered Chapter 7 bankruptcy and was delisted in 2024. Its experience illustrates some of the commercial, manufacturing and financing challenges that early-stage materials companies may encounter.

The invisibility cloak will continue to capture public imagination, but it may ultimately become one of the least commercially important products created by metamaterial science. The more immediate transformation is already happening inside optical sensors, satellite terminals, radar systems and advanced communications equipment.

Metamaterials could make these systems smaller, lighter, more efficient and increasingly software-defined. In doing so, they may create a new layer of demand for gallium, germanium, tantalum, indium, antimony, tellurium and other strategically sensitive materials.

The critical minerals opportunity will not be measured by tonnes alone. It will be measured by the value of the technologies that cannot function without them.

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