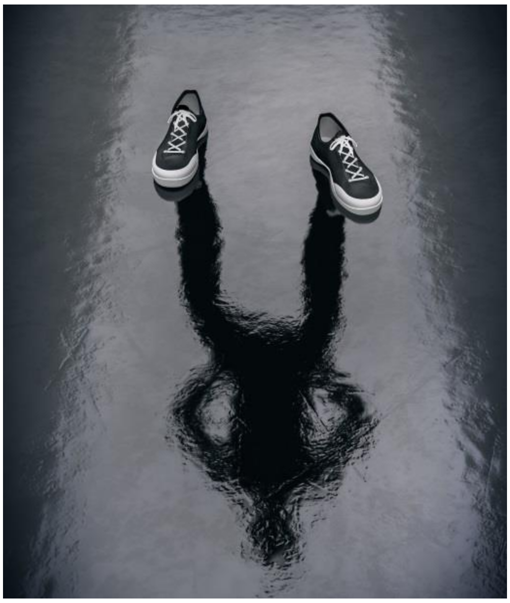
What if we could make ourselves invisible to others?

Through developments in the field of metamaterials, we may be able to create products with surprising capabilities, from making DNA visible to making buildings invisible, but have we considered the risks, as well as the benefits?

Metamaterials are materials that are designed and structured in a way that gives them unconventional properties, which are not usually associated with the material from which they are produced. They can be produced either by creating new materials to work with, making use of advances in nanotechnology, or by finding new ways of working with conventional materials, such as metal and plastic. Metamaterials involve a broad and loosely defined group of technologies with a wide range of novel avenues of development. Some are designed to manipulate electromagnetic and acoustic waves, so that they interact differently with sound, light, radio, microwaves and x-rays. Since the surface of metamaterials can affect their reaction to electromagnetic waves, they could in theory be used to transport light and other electromagnetic waves around an object, making them invisible to an observer. Different metamaterials could be used to manipulate different kinds of electromagnetic waves, thus creating cloaks for different kinds of sensors, from human eyes to x-rays and radio waves. Metamaterials could also be deployed to manipulate other kinds of energy such as sound and seismic waves, which would pass an object as though it were not there.



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This has led to reports of the imminent invention of invisibility cloaks although, until now, scientists have only succeeded in partially cloaking small objects from a fixed observation point under laboratory conditions, with invisibility achieved only for a limited range of non-visible electromagnetic waves. While the invisibility cloak akin to that of our popular imagination remains some distance away, we may be able to divert light as well as sound and other energy waves to make objects appear invisible (cloaked from electromagnetic waves), or to create earthquake-proof buildings (cloaked from seismic energy) and silent spaces (cloaked from sound waves).

Until now, the idea has been applied to simpler problems, such as a cape which can hide a person from a drone's infrared and heat sensitive cameras (although not from visible light). In the medium-term, we may expect increasingly sophisticated uses of metamaterials in our daily lives. For example, a building which normally blocks mobile phone signals could be made invisible to the microwave spectrum that carries mobile data, or a submarine which is usually detected by sonar can be made invisible to the sound waves used to detect them. Metamaterial antennas promise more powerful, precise and controlled communications.

The use of metamaterials to manipulate energy could have many other potential application areas. For example, they can be used to build faster, smaller and higher-performance computer components which use light instead of electricity. Another important area of development is medical instrumentation, with metamaterials already being used to improve the resolution and signal to noise ratio of MRI scanners, enabling faster and more accurate analysis and diagnosis. Researchers are also applying metamaterial technology to lenses, developing 'superlenses', which can be used to observe incredibly small objects such as viruses and even DNA. These superlenses can also be used to produce wireless charging technologies for electronic devices.

EPRS | European Parliamentary Research Service
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Scientific Foresight Unit (STOA)
June 2016 - PE 581.896

Potential impacts and developments

Some estimates suggest that the total global market for metamaterials will grow from €300 million to €900 million over the next five years, and may exceed €2 billion by 2025. Aside from the economic importance of metamaterials, the technology may have some important social impacts, both positive and negative. For example, the manipulation of radio and microwave signals could improve international connectivity, but could also predictably lead to new vulnerabilities in terms of privacy, security and accessibility. While there have been some calls for a broad debate amongst ethicists, policy-makers and the public, most coverage of metamaterials has focused upon potential positive impacts such as improving communications and hiding unattractive buildings from view. There are very few critical analyses of these promises, and little attention has been paid to drawbacks, such as potential risks. For example, if these materials behave drastically differently to those with which we are familiar, how can we be sure that they will not have consequences other than those intended, or interfere with human health and the environment?

Several applications of metamaterials are dual use, with synergies between developments for commercial and military applications. Many emerging technologies are dual use, inviting questions about whether they are likely to lead to infringements of the customary laws of armed conflict. Here, for example, the principle of distinction may be challenged in a situation where combatants or equipment are hidden amongst civilians.

Anticipatory law-making

The use of metamaterials raises a wide range of privacy, environmental, dual use and misuse considerations. More specifically, these materials may even modify our legal perception of privacy, triggering the need to redefine the right to know[1] and the right to be forgotten,[2] and opening discussions on redesigning traditional informed consent modalities. In general, metamaterials and their extensive (invisibility) uses in public spaces may blur the lines between private and public spheres, which in effect will bring a new perspective to the traditional legal distinction between public and private.

Moreover, the use of metamaterial-based devices in illegal activities may necessitate a substantial adaptation or reconceptualisation of the main tenets of procedural law, criminal law and the law of evidence, especially when it comes to the allocation of the burden of proof, the exact role and weight of expert witnesses, and the variety of admissible evidence used in judicial proceedings. The use of these particular technological products could also blur the lines between civilian and military products/applications which in effect may facilitate potential misuse including terrorist use (easier procurement, concealment), calling into question the efficiency or even thoroughness of the relevant EU export-control rules.

Metamaterials made of nanomaterials which may pose novel toxicological risks are also expected to lead to the widening of the scope of the REACH framework, as well as of all regulatory initiatives on nanotechnology at the EU level. Electromagnetic metamaterials may have a significant effect upon public health and safety and eventually lead to the modification of the EU framework that sets minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents. At the same time, the high scientific uncertainties that transcend the field of nanometamaterials beg the question of the terms and conditions for the use of the precautionary principle.

Making an object, weapon, or even people invisible to security scanners would raise difficult questions regarding the notion and attribution of legal responsibility in contractual or even criminal terms. Last but not least, making arms and soldiers invisible may clash with international humanitarian norms that are based on the principle of distinction between civilians and combatants.

[1] In the context of data protection, the right to know refers to the right of a person to know exactly if and how his/her personal details are being held by an organisation or individual.

[2] According to the recently adopted General Data Protection Regulation, a 'right to be forgotten' refers to the situation when an individual no longer wants her/his data to be processed, and provided that there are no legitimate grounds for retaining it, the data is deleted.

This 'What if ...?' publication is a product of the Scientific Foresight Unit (STOA) of EPRS. More information on the unit's activities can be found at http://www.europarl.europa.eu/stoa/ and http://epthinktank.eu/author/stoablogger/