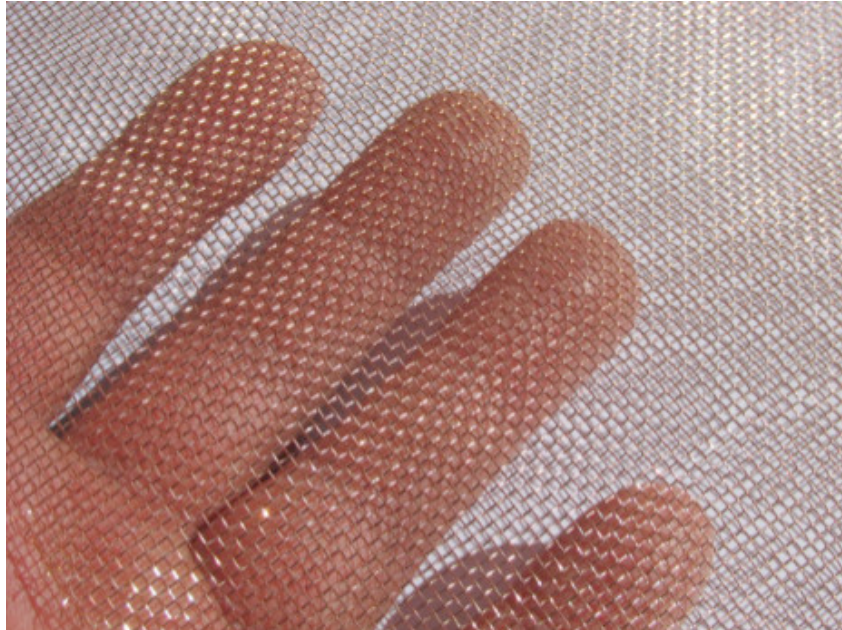


## Choosing materials to shield a home against microwave radiation



**Several types of shielding materials are available to protect a house against mobile phone base stations, wireless networks, smart meters, etc. This article discusses cost-effective choices and also considers the needs of people with chemical sensitivities.**

*Keywords: how to shield, microwaves, EMF, RF, radio frequency, wireless, Wi-Fi, WLAN, cell tower, base station, smart meter, radiation, electrical sensitivity, MCS, Faraday, shielding material*

### **Shielding materials**

Wireless gadgets work unhindered in most modern homes located in areas with good wireless reception. The microwave signals pass right through plastic siding, plywood, gypsum sheet rock, insulation, shingles and plain window glass. It is like sunshine through a window, even though we can't see it.

To block the radiation we use shielding materials on the walls, ceilings, floors, windows and doors of a house. There are a large variety of materials available; some can be purchased at building supply stores or even grocery stores, while others must be obtained from specialty retailers.

The materials specifically designed and marketed for shielding all come with information on how well they shield different frequencies (if not, pass them over). Be aware that such data is for optimal conditions, while real-life results will be much less.

The shielding effect of all materials depends on the frequency of the radiation. Some materials are best suited for microwaves, while others are better suited for lower frequencies. This article is only concerned about microwaves and does not cover special low-frequency materials, such as mumetal.

The available materials fall into two groups: absorptive and reflective. Each type has its benefits and drawbacks.

### **Absorptive shielding**

Absorptive shielding includes some common building materials, such as concrete, bricks and wood. Soil, especially clay, also absorbs microwaves. There are also special microwave-absorbing materials made of carbon.

Absorptive shielding works mainly by absorbing energy from the microwaves and turning it into heat. It does that as the radiation passes through the shield, so the effectiveness depends on how thick the shield is. If the thickness is doubled, then it will shield twice as well. To make it ten times as effective, the material has to be ten times as thick. The amount of energy absorbed is so little that the material does not get warm.

Salt water is a good microwave absorber, which is why submarines have to stick their antennas above the water to talk to their base. (Or use a special, very slow, extremely low-frequency communication systems while submerged). Moist clay, concrete and lumber are more absorbent than when they fully cure or dry out. Porous materials may therefore provide better shielding in wet climates (such as Europe and coastal parts of the United States) compared to dry climates (such as the American West). Unfortunately, there are no studies on how much ambient humidity affects the shielding effect.

The ability of the materials to absorb microwaves depends on the frequency. They usually become better as the frequency increases. Research at the National Institute of Standards and Technology (NIST) in the United States found that a wall made of either one, two or three layers of bricks provided the following shielding at increasing frequencies:

	500 MHz	1 GHz	2 GHz	5 GHz	8 GHz
1 brick	0	3.5	5.5	15	16
2 bricks	3.5	5.5	7.5	32	14
3 bricks	4	7	10.5	32	27

Brick shielding effect in decibels (dB) for commonly used microwave frequencies. From NIST report NISTIR 6055 (1997)

The above table shows the shielding in decibels (dB). A tenfold reduction is 10 dB, while a hundredfold reduction is 20 dB. These are not impressive numbers for today's microwave pollution that is typically strongest around 1 to 2 GHz, and often so strong that reductions of 30 dB or more are needed.

The same report found much better shielding with concrete, but that was because the samples they used were not fully cured. Later research at a military university in Germany, using fully cured concrete, found that a 6 ½ inch (16 cm) concrete wall only shields 11 dB (twelfefold) at 2 GHz and even less at 1 GHz. To get a hundredfold (20 dB) reduction at 1 GHz, one would need a 19 inch (48 cm) thick concrete wall. That would be impractical and very costly.

The Germans tested more than a hundred materials and found some to be better, such as autoclaved aerated concrete, which is a common material in Europe. A wall of this material would still need to be 12-18 inches (30-46 cm) thick to provide a hundredfold (20 dB) shielding effect.

The German results are available in the report *Reduzierung hochfrequenter Strahlung im Bauwesen*, by Peter Pauli and Dietrich Moldan, (2015). Their 2000 report, which is available in English translation, does not have the data for fully cured concrete, only for the fresh concrete.



*Walls of brick or concrete absorb microwaves, but rarely enough to provide good shielding.*

In real-life housing, built with absorptive walls, there is rarely more than a tenfold (10 dB) shielding effect. An apartment building in Zurich, Switzerland, was built in 2013 for people with chemical and electrical sensitivities. The building provides only a fivefold (7 dB) shielding of the ambient radiation, despite all the efforts, including the use of special carbon absorbers.

Using absorptive shielding alone is no longer realistic in today's world.

### **Reflective Shielding**

Reflective shielding materials are all metallic and mainly work by reflecting microwaves back like a mirror. This principle is used in satellite dishes and radio observatories, that are made of metal and formed so the incoming microwaves are reflected back to a single point to concentrate the signal for the receiver.

The thickness of the material is not so important with reflective microwave shielding since it works by reflection, i.e. on the surface. Aluminum and copper are excellent materials for this type of shielding, though any metal can be used. The exception is oxidized metals, such as magnesium-oxide and iron-oxide (rust) as they no longer conduct electricity (a little rust on the surface is probably okay if it doesn't hinder conductivity).

Using reflective shielding has some possible drawbacks:

- EMFs trapped inside
- Schumann frequencies dampened
- stray currents
- sensitivities

Both sides of reflective shielding material will reflect microwaves and radio-frequency EMFs. This means that radiation generated inside the shielded area will reflect back from a metal shield and keep bouncing around. This can dramatically raise the radiation level throughout the house, not just near the source.

The table below shows the radiation level at various distances to a cordless phone base, measured both outside and inside three shielded houses.

	6 ft / 2 m	10 ft / 3.2 m	20 ft / 6.5 m
Outdoors	1370	975	267
House #1	2263	1872	8256
House #2	3492	6979	3275
House #3	21,600	3164	2852

The measurements are all done as line-of-sight, i.e. no walls between the phone base and the meter. The numbers are in  $\mu\text{W}/\text{m}^2$ . The radiation level drops rapidly with distance when outside, but inside the houses the radiation level is dominated by the reflections and not by distance. The rooms were all oddly shaped, which explains the widely varying measurements.



*Wireless gadgets should not be used inside a shielded space, since reflections can greatly increase the radiation exposure.*

The same effect does not happen with low-frequency magnetic and electric fields, such as coming from electrical motors in refrigerators and vacuum cleaners. (We compared the electrical and magnetic fields from a 700 watt electrical motor inside a shielded room to when it was in the middle of a yard – the readings were all the same.)

The Earth's atmosphere generates some natural frequencies, called the Schumann resonances. They are extremely low frequencies from 8 hertz up to 45 hertz. Shielding these frequencies can give sleep problems. Fortunately, it is very difficult to shield such low frequencies. It takes multiple layers of thick steel,

which would be overkill when shielding microwaves. This therefore does not seem to be an issue.

Since reflective shielding uses metals that conduct electricity very well, there is an increased risk of stray electricity running where it is not supposed to. In a regular house, stray electricity can sometimes be found on water pipes, gas pipes, studs, air ducts and siding made of metal. This can cause high levels of electric and magnetic radiation in a house, possibly even shocking the people living there. The same kind of problems can happen with metallic shielding if not installed carefully.

Metals do have an odor to them, especially raw plates of steel and aluminum. This can be a problem with large surfaces. Aluminum foil is much better tolerated. It can also help to hide the metallic surfaces inside walls, under paint or with an anodized surface treatment. It still may not work for everybody.

There are people who seem to be energetically affected by metals. They continue to have trouble, even when all other possibilities seem to be ruled out. This issue is poorly understood, but seems to affect very few people.

### **Aluminum foil shielding**

Aluminum foil is a cheap and effective material to use for microwave shielding. The research at the German military university shows that 0.05 mm (2 mil) aluminum foil can achieve shielding above 50 dB (hundred thousand fold) at frequencies from 500 MHz to 10 GHz. Regular “heavy duty” aluminum foil, as sold in American grocery stores, is 1 mil (0.025 mm) thick and should have a very similar shielding effect.

Aluminum foil is available in a variety of forms, such as rolls, self-adhesive tape and attached to insulating foam boards. It is also available laminated with plastic or brown paper, such as sold for use as vapor barriers and heat reflectors.

The thin (unlaminated) foils can be attached to wallboards using wall paper glue (preferably a non-toxic version).

The laminated foils are better for mounting inside a wall (behind the wallboard), to cover floors and stapled to walls and ceilings as temporary installations.

Aluminum plates are usually not used, unless there is a need to shield lower frequencies, such as from radio stations or electrical equipment. Be aware that aluminum plates also tend to have an odor that can be a problem for sensitive people, unless the plates are anodized or otherwise sealed.



*Aluminum foil is cheap and effective shielding that can be installed in several ways.*

Please see the separate article with instructions on installing the various shielding materials, including how to avoid condensation and mold problems.

### **Copper shielding**

Copper conducts electricity better than aluminum and is therefore better at shielding microwaves, but it is also much more expensive.

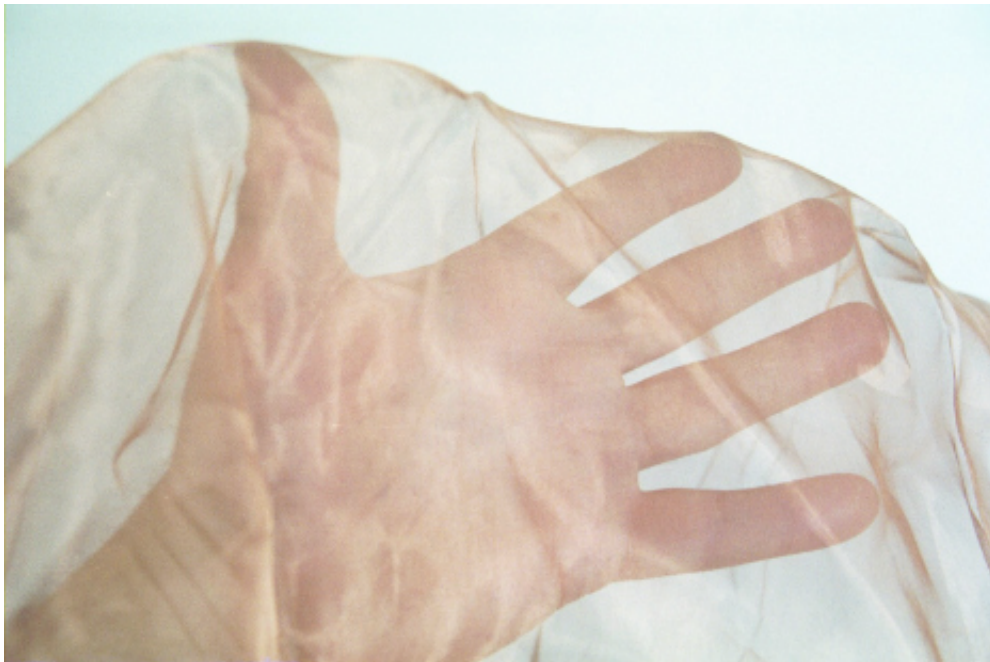
Copper is available in a variety of forms, such as fabrics, meshes, foils, tapes, sheets and paints. Since copper is expensive, it makes sense to use it only where

cheaper materials can't do the same job. It is possible to build a well-shielded house with very little use of copper shielding, or none at all.

Copper is usually used in the form of fabrics or meshes. In general, the finer the mesh or fabric, the better they shield at higher frequencies. For frequencies above 5 GHz aluminum foil outperforms most copper meshes. The newer Wi-Fi systems transmit between 5 and 6 GHz. The new 5G system will use yet higher frequencies where mesh may be worthless.

The copper meshes are rather stiff and look like the insect netting that is placed over windows and enclosed porches. They can be made of pure copper, or combined with a cheaper metal such as aluminum. They are used where light, air or vapors must be allowed through, but flexibility is not needed, such as for windows and ventilation holes.

The copper fabrics are made of polyester, nylon or cotton, which a thin coating of copper. Some of the fabrics also contain silver. They are very flexible and can be used as shielding curtains over windows or canopies draped around beds. They can also be used to cover walls and ceilings where it is not possible to use foil, such as over wood panelling, textured paint or if the shielding must be removable such as in rented houses and apartments.



*Shielding fabrics are well suited for some situations, but they are less effective at higher frequencies and may be worthless against future 5G signals. They are also costly and often not tolerated by people with chemical sensitivities.*



*Meshes of pure copper are better tolerated by people with chemical sensitivities than the fabrics*

The fact that light, air and water vapors pass through meshes and fabrics is sometimes a reason to use them.

A major issue is that the fabrics are usually not tolerable by people with MCS and it is rarely realistic to improve on them by washing or airing them out (see later). People with MCS should consider using meshes or other materials instead.

### **Shielding with steel**

Steel is another option for shielding. It is less conductive than copper and aluminum, but steel is both cheaper and stronger than any other shielding material and is better at shielding low-frequency EMF. Steel siding and roofing can provide effective shielding of a house.

Fine meshes of stainless steel can be used where light, air or vapors need to pass through, and the shielding material needs to be strong enough to withstand wind movement, such as for windows and ventilation openings.



*Steel siding and roofing are good shielding materials.*

Chicken wire is not usable as shielding material since the holes are too big to block microwaves. They are effective for frequencies below 500 MHz, but not any higher.

### **Shielding paints**

Shielding paints contain copper, silver or nickel, which forms a thin layer of shielding when painted on a surface. They can be covered with a regular paint to look nicer. These paints are costly and most of them have very toxic ingredients, which makes them unsuitable for homes of people with chemical sensitivities. There are less-toxic products available, but be sure to test for tolerance before using.

The shielding effect of the paints varies dramatically. The German military university tested 11 brands and found them to vary between zero and 38 dB, i.e. some products were nearly or totally worthless. Be aware that most of the paints are for indoor use only.

This author has no experience with shielding paint and doesn't know anybody who does. I don't know how well they work in practice, how well they cover a wall, how long they last and how well they off-gas.

Shielding paints may be best suited for projects where the foils, meshes and fabrics cannot do the job. This may be for aesthetic reasons, on difficult surfaces

or for existing houses. It certainly seems like an enticing idea to shield a room by painting the walls, or shield a whole house by painting the facade.

These paints may be a good option when renting an apartment or house. Landlords commonly paint an apartment before renting it out – some jurisdictions actually require it. Perhaps a landlord would be willing to use a shielding paint, with a regular paint on top, if the new renter supplied the shielding paint and paid the extra cost.

### **Shielding windows**

Shielding windows are available. Low-E glass has a very thin coating of a special stainless steel alloy to reflect infrared light (heat). This happens to be a pretty good reflector of microwaves as well. The coating is so thin light passes through and this limits its microwave shielding effect to about 20 dB.

Low-E windows are available with dual-pane or triple-pane glass. The coating is usually on one surface only – one that faces the dead air space. We have heard that some brands do have two coated surfaces; these windows may offer better shielding, but we have not seen any data and don't know what brands.

Manufacturers are rumored to be developing non-metallic coatings for their low-E windows. This is because most people actually *want* microwaves to pass through their windows. These coatings have not yet (2017) become available commercially.

Most window tinting to install on car windows do not have a metallic film. A few products do and are usually marketed as “heat shield” film. The products have a limited life span and the manufacturers do not recommend installing them in houses.

There are clear plastic sheets available that have been specifically developed for shielding purposes. They are not marketed for shielding windows and it is doubtful that they will last long when irradiated with sunlight and heat all day.

### **Shielding building materials**

A number of special shielding building materials have been marketed in Germany, but are presently not available in the United States. These include drywall and plywood sheets, stucco, clay and sandstone products. Almost all of them provide reflective shielding from iron particles (magnetite) that is incorporated into the material. The shielding effects vary.

A German manufacturer, Knauf, produced a gypsum wallboard that used absorptive shielding, using carbon additives. It provided 15 dB shielding across a wide spectrum of frequencies, but was not a commercial success and was discontinued.

A benefit of using these various building products, instead of metallic shielding materials, is that they do not conduct electricity well and they would not need to be safety grounded. They are also more aesthetically pleasing.

### **Other shielding materials**

There are several other shielding materials available. Some are very expensive, some are better suited for other frequencies (such as mumetal). It is easy to become blinded by the impressive looking sales brochures for these materials. In praxis, these expensive materials are rarely needed for a regular house-shielding project. They can be like buying a Ferrari engine and then mounting it in a basic Volkswagen.

Shielding a house is like building a chain: the weakest link determines how strong the chain is. Using shielding materials rated for 60-80 dB (more than a millionfold) is undermined by poorer shielded doors, windows, slits and holes, so the overall result can still be just a 20 dB (hundredfold) shielding effect.

### **Terrain shielding**

The terrain can provide some shielding, such as having a ridge or hill between the house and a transmitter. This author has tested three different locations that each provided about tenfold (10 dB) shielding. They all consisted of dry and sandy desert soil. Perhaps hills consisting of moist clay would work better.

Dense stands of live trees are said to provide good shielding. This method is common among severely sensitive people in Sweden, who relocate to cabins in the forests. However, actual data is scarce.

A deep basement can provide effective shielding if combined with a shielded ceiling and shielding of any walls above grade.

Terrain shielding will become less effective once satellites and, perhaps, high-altitude balloons will beam wireless Internet services from above.

## **Shielding for people who are also chemically sensitive**

Some of the shielding materials are problematic to use for people with MCS. We are aware of the following issues:

- shielding fabrics
- shielding paints
- conductive glues

Shielding fabrics are made of copper or silver that is sprayed on a thread that makes it light, flexible, strong and somewhat durable. The thread is usually polyester, but can also be nylon or cotton. People with MCS tend to have trouble tolerating these fabrics, especially those based on polyester. The few cotton products appear to be more tolerable, but try with a sample before buying a large amount of the fabric or installing it where it is difficult to remove.

It does not seem to help to offgas the fabrics for a year or more. Washing the fabrics several times does not work as the sprayed-on copper or silver will flake off in the washing machine and make the fabric ineffective after just a few washings.

Shielding paints have a reputation for being very difficult for people with MCS, though this author has no experience with them. Use great caution if trying these paints. Make sure to do a large-scale test yourself before using, do not rely on what other people say or any claim by the manufacturer. In any case, expect to have to vigorously ventilate the room for months before it can be used safely by someone with MCS – regardless of any claims of “non-toxic” or “no-VOC.”

Metal tapes are available in aluminum, stainless steel and copper. Some have a special conductive adhesive. The adhesives can be very toxic – one sample of copper tape with a conductive glue was still unacceptable after offgassing for a year. Even though most of the glue is covered by the tape, enough fumes can escape through the edges to be a problem especially when a lot of tape is used.

With a generous overlap of a seam, perhaps by at least ½ inch (1 cm) on each side, conductive glue may not be needed. But non-conductive glues can be a problem as well. Make sure to test the chosen brand before using a lot of it.

This author prefers the aluminum tape with acrylic adhesive from E. L. Foust in Chicago, USA. The Polyken brand is second best.

### **More information on shielding**

This website has additional articles about shielding electromagnetic fields, including the other parts of this article series. They can be found on:

[www.eiwellspring.org/shielding.html](http://www.eiwellspring.org/shielding.html)

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