Textile chemistry

12. Textile finshing

Jakub Wiener

Dividing final finishes

Depending on the achieved property, we divide the finishing of textiles into:

Appearance combing, spraying, grinding, almonding, calendering, decatting, these are mainly mechanical adjustments of textiles. softening, weighting, filling.

Stabilizing non-shrinking, non-shrinking, non-ironing, non-flaking, anti-wrinkle, etc.

Protective hydrophobic, oleophobic, non-staining, anti-static, non-flammable, anti-microbial, etc.

Mechanical treatment of textiles

Combing - Combing creates a pile on the surface of the fabric. In addition to the aesthetic effect, the combed fabric has better thermal insulation properties.

Shearing - The aim is to adjust the final length of the pile over the surface fabric. For this purpose, there are various cutting machines of different designs, which can be used to adjust the height of the cut.

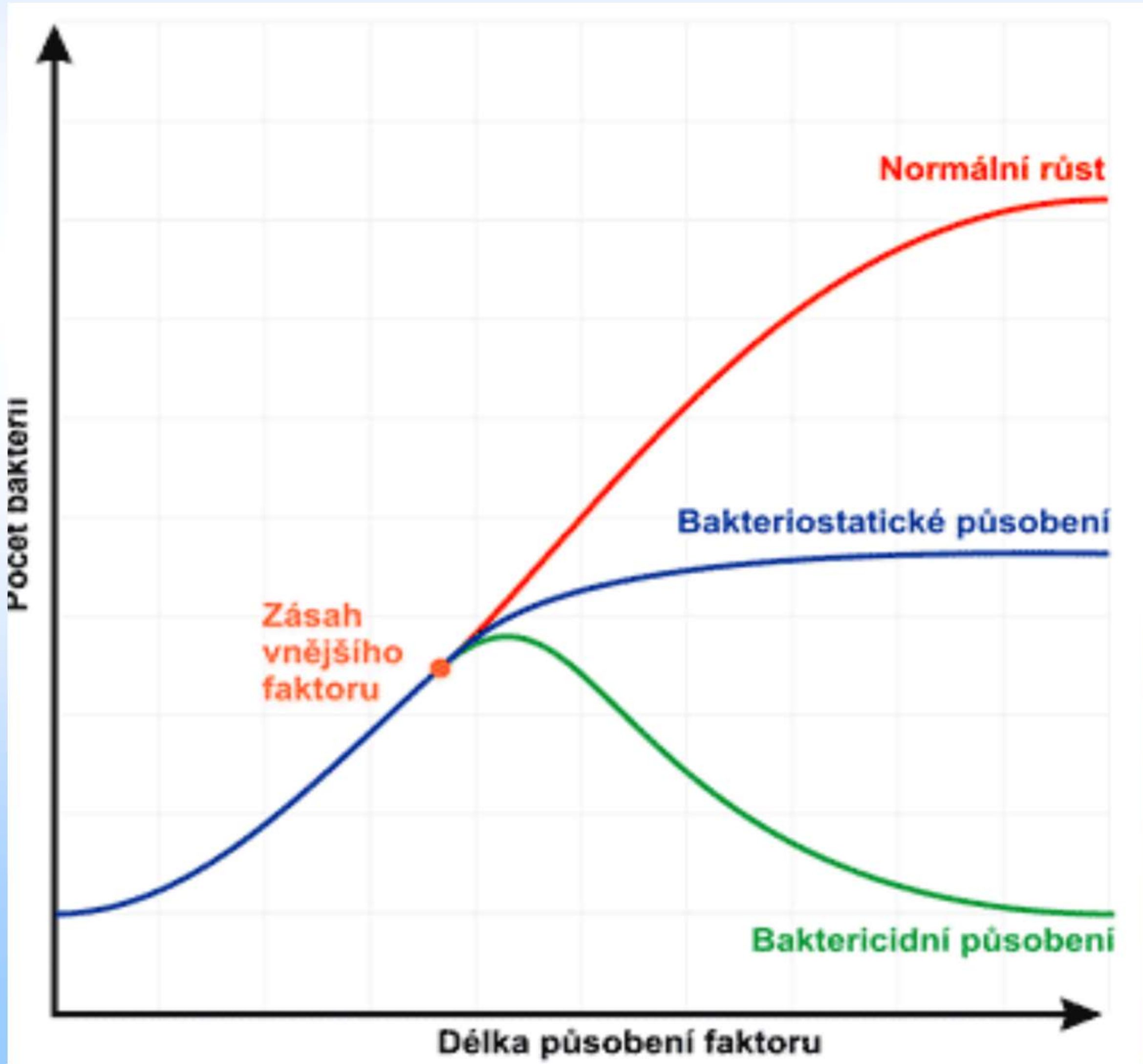
Calendering - In calendering, the full width of the fabric is passed between rollers pressed together at cold or elevated temperatures. In the case of fabrics, the yarn is flattened and the inter-weave spaces are filled. The smoothness and lustre of the fabric is increased.

Sanforization - when washing textiles, the products are shrinking. For example, untreated cotton fabric can shrink by up to 15% after washing. This shrinkage can be reduced by treating the fabric with so-called compression shrinkage or sanforisation.

Antimicrobial treatment

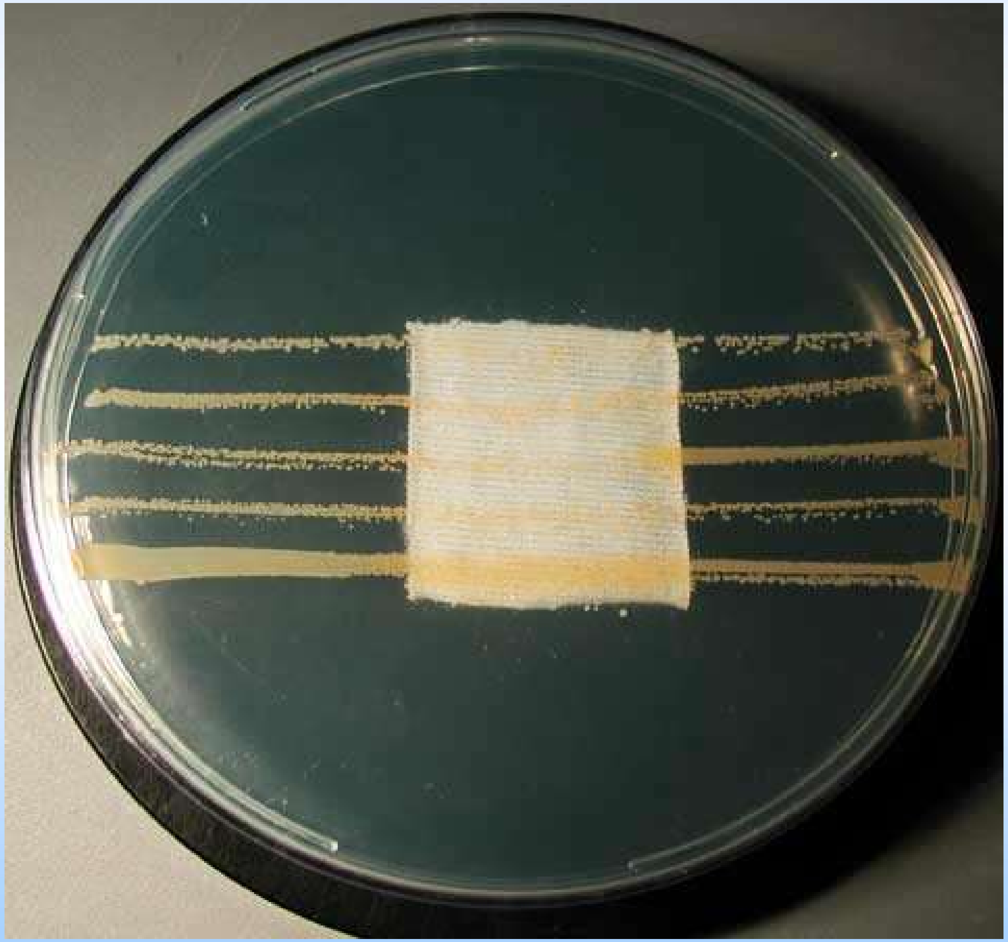
Textile reasons: loss of mechanical properties, odour
Hygienic: odour, skin diseases

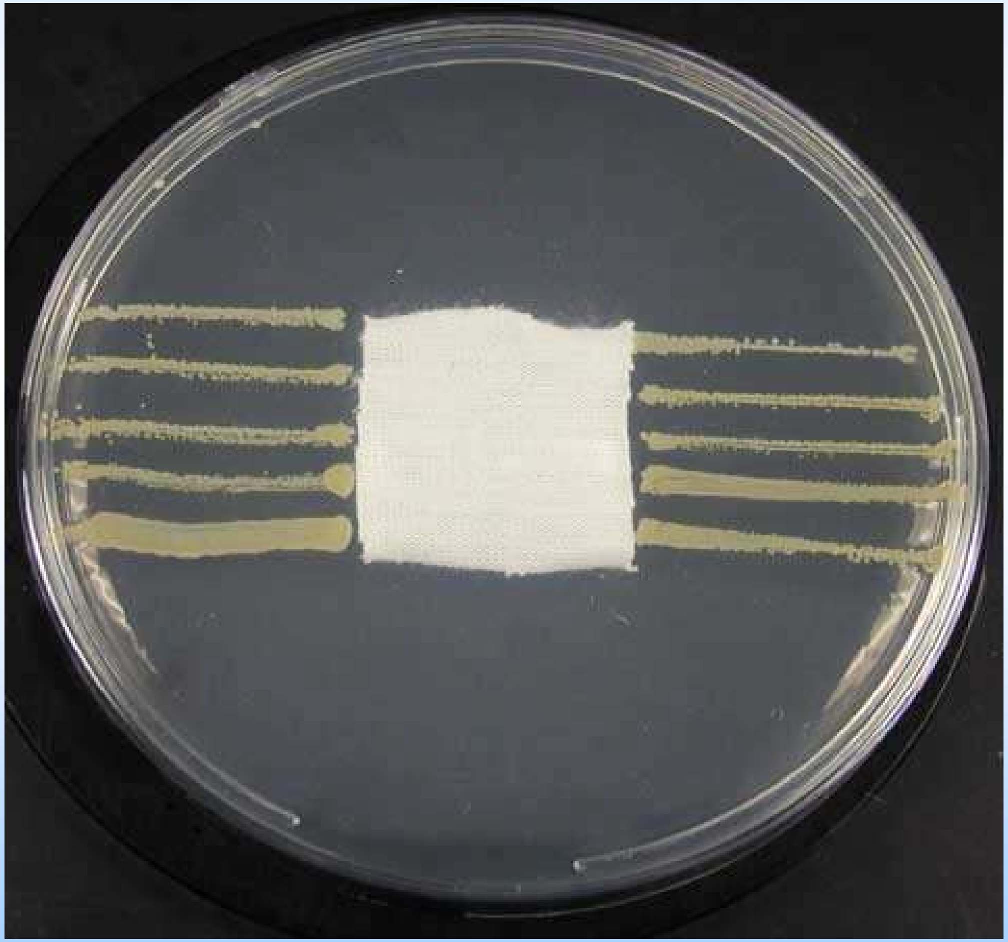
Effective control of bacteria, mould and fungi



application: in the polymer mass before extrusion or during finishing of the fabric

AATCC 100 Antimicrobial test





Hydrofobní úprava

1/ impermeable = coating

A waterproof finish that must resist the high pressure of the water column. It is done by coating or sealing with latexes, thermoplastic resins, etc. The applied film must be sufficiently flexible, strong and with sufficient adhesion. These treatments are not suitable for clothing as the fabric is impermeable and the wear is unhygienic. Their use is mainly directed to canvas fabrics of all kinds.

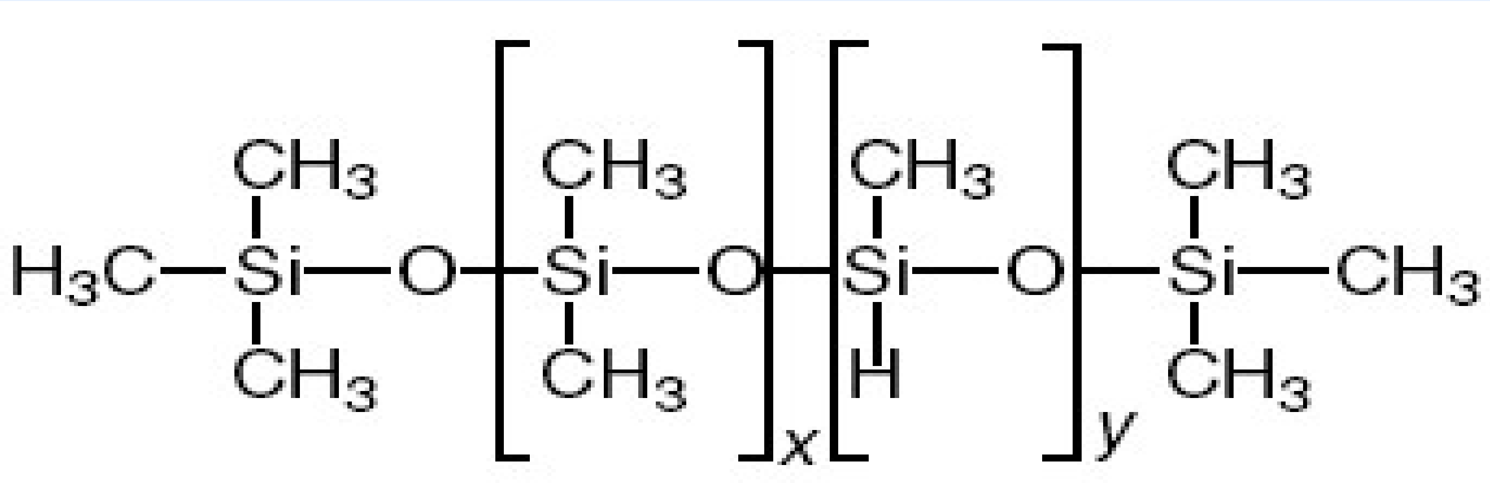
Hydrophobic treatment

2/ breathable

applied mostly to sportswear. It is done by wrapping the individual fibres with a hydrophobic thin film so that water cannot penetrate them. However, the air permeability is maintained. It is suitable for outerwear, windbreakers,

raincoats and workwear, tents, etc.

3 types of chemicals: Alkanes, Silicones, Perflouralkanes (Teflon)



Silicons - Hydrophobic treatment

Advantages:
sufficient stability of the finish
easy application
versatility of use for all types of fibres
excellent de-feathering effect
pleasant, so-called "silicone" feel

Disadvantages:
Worsens wrinkling, causes seam shifting, have only average resistance to washing and dry cleaning.

Hydrophobic treatment - testing

An instrument for measuring the height of the water column:

1 - pressure at which the first 3 drops penetrate

2 - time for the first 3 drops to penetrate at constant pressure

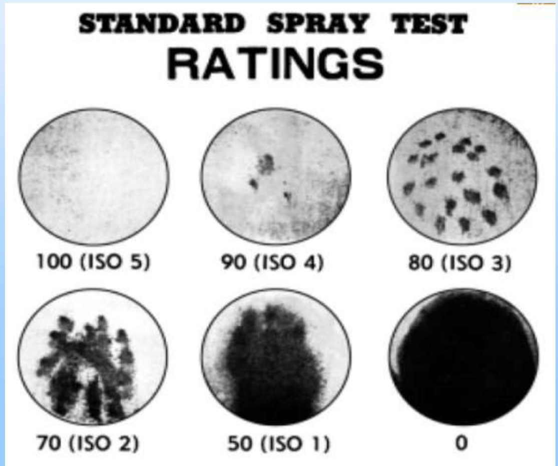
3 - the amount of water that has penetrated in a certain time at the set pressure.

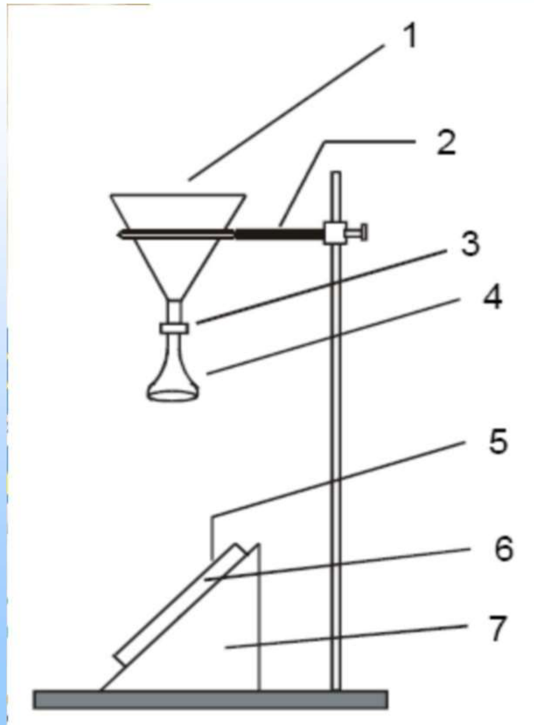
The limit for the suitability of the barrier fabric in outdoor use is a minimum of 10,000 mm (kneeling in snow approx. 10,000 mm of water column pressure, depending on the weight of the kneeler).

Hydrophobic treatment - testing

Spray Test - the essence of the test is to clamp the test sample in a frame that makes a 45 angle with the pad, face up, and spray it with 250 ml of distilled water to flow in 30 sec. Immediately after sprinkling, remove the frame with the specimen, turn it face downwards and, by striking it twice against a hard object, remove any drops of water adhering to the surface of the specimen.

1 - funnel, 2 - circular holder, 3 - rubber circular connector, 4 - attachment for scraping water, 5 - sample, 6 - sample clamping frame, 7 - base





Membranes

Alternative to hydrophobic treatments (hydrophobization of fibres) / coatings (sealing the fabric structure with a polymer)

Better properties - vapour permeability can be ensured with extreme water resistance

Two possible principles:

* hydrophilic membrane (membrane has no pores, water is transported by diffusion in the polymer)

* hydrophobic membrane has very small pores (water vapour passes through the membrane in a gaseous state)

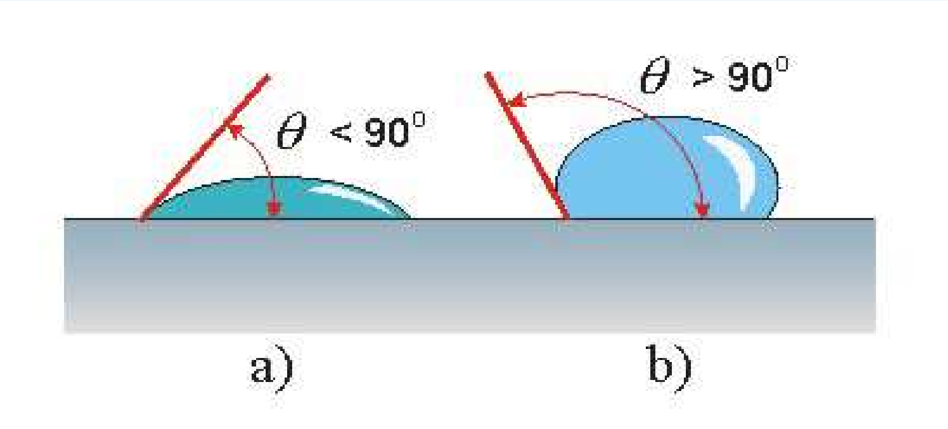
Oleophobic treatment

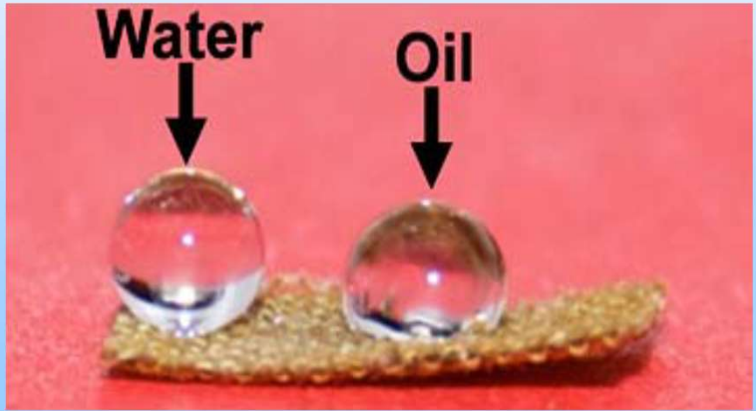
Textiles with oleophobic treatment also repel oily substances and greasy dirt.

Tablecloths, clothing for kitchens... Home textiles

The principle of oleophobic treatments is based on the well-known observation that a liquid does not wet a surface unless its surface tension is greater than the surface tension of the body.

This therefore means that the oleophobic treatment must reduce the surface tension of the fabric. This can be achieved by means of perfluorinated compounds anchored to a suitable polymer chai





Oleophobic treatment

Means are applied :

from an aqueous environment (emulsions)

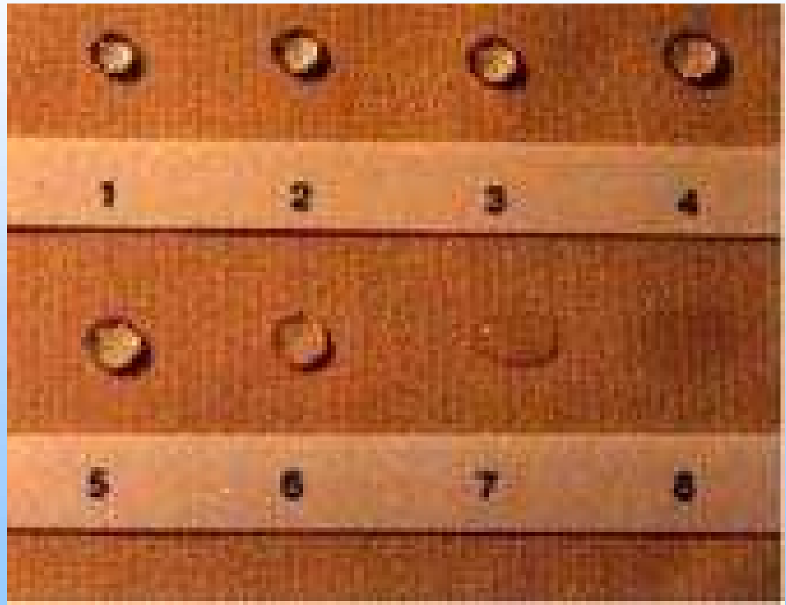
from organic solvents

Permanent treatments with these agents require drying at 100 °C and fixing at 150 °C for 5 minutes.

Evaluation of oleophobic treatment

-The test for evaluating the effectiveness of oleophobic treatment is based on wetting tests of the treated fabric with a range of liquids with decreasing surface tension.

The value of the degree of oleo-repellency is given by the highest number of liquids whose droplet applied to the test sample does not wet the surface for 30 seconds



Soil repellent

- the fabric is protected from soiling, repels all types of dirt

The principle is to reduce the surface tension of the fabric below 30 mN/m (oils have a surface tension of approx. 30 mN/m)

The most effective agents are compounds based on perfluoroalkanes

From milk dispersion

- Catalysts based on isocyanates
- Fullerene impregnation - drying to 100°C or 140-160°C

Flame retardant finish

Reaction to ignition (ignition)

Release of intermolecular bonds occurs. These processes take place between Tg and Tm (glass transition temperature and melting temperature) As the temperature is further increased, depolymerization occurs, the degradation of the supramolecular chain - pyrolysis, when solid, liquid and gaseous components are formed (The higher the rate of pyrolysis, the faster ignition and combustion occurs)

Ignition

Ignition by an external ignition source with an ignition temperature Tz and self-ignition. When the auto-ignition temperature Tz is reached, the combustible gases from the pyrolysis products are ignited.

Combustion

exothermic process - heat energy and light radiation are produced When the amount of energy produced by the combustion of the pyrolysis gases is greater than the energy required to pyrolyse the fibrous material, the flame produced by the ignition burns even after the ignition source is removed

Flame retardant finish

Limit Oxygen Iindex- LOI

Data on flammability of materials and effectiveness of non-combustible treatments

Expression of the lowest oxygen concentration in the mixture with nitrogen (%)

Low LOI value - material burns

Materials with a LOI value above 25 - highly flammable

Materials with a LCR value below 20 - highly flammable

Flame retardant finish

fibre	LOI %
wool	25 %
cotton	19 %
viscose	20 %
PES	21 %
PA 6	20 %
Nomex	30 %
Kevlar	29 %

$$LKČ = \frac{[O_2]}{[N_2] + [O_2]} \cdot 100\ [\%]$$

Flame retardant finish

Polymer flame retardancy theory

Layer theory - protective film on the polymer surface

Cooling theory - energy extraction from the combustion zone

Gas theory - formation of non-flammable gases and vapour

Flame retardant finish - testing

Depending on the area in which the fabric is used, there are different ignition and burning conditions.

There are 4 geometric arrangements of the samples in the space:
Horizontal (method H),
Vertical (V method).
Oblique
Arched
In terms of the arrangement of the ignition methods we distinguish:
Edge ignition
Flat ignition

- **Zápalkový test**
- **Cigaretový test**
- **Maticový test (M16)**
- **Tabletový test**

Antistatická úprava

Antistatická úprava slouží k odstranění nežádoucích účinků elektrostatického náboje syntetických vláken, která se nabíjejí elektrostatickou elektřinou při výrobě i nošení tkanin a pletenin.

Elektrostatický náboj způsobuje nežádoucí přilnavost a špinivost.

Tato úprava se provádí antistatickými chemickými přípravky, které působí dočasně nebo trvale.

Antistatic treatment

Surface resistance vs. antistatic properties

$10^6 - 10^7\ \Omega$ . . . Excellent, $10^8 - 10^9\ \Omega$ . . . good

$10^{11} - 10^{13}\ \Omega$ . . unsatisfactory

	resistance Ω	Humidity %
wool	10^7	12
cotton	10^8	8
PA	10^{12}	4
PAN	10^{14}	1
PES	10^{13}	0,4
PP	10^{15}	0,2

Antistatic treatment

chemicals for temporary antistatic treatment I

- Inorganic and organic salts
  (rarely used, usually as a synergistic component of other agents)

polyalcohols and polyethylene glycols
  (alone or in combination with tensides)

- polyelectrolytes
  (mainly salts of polystyrene sulphonic and polyacrylic acids, also polymerizations of esters of acrylic or methacrylic acid with oxethylated ethanolamine)

tensides of all kinds

anti-pilling treatment on textiles

Fabrics and knits made from synthetic fibre yarns, especially PAN or PES, are prone to pilling.

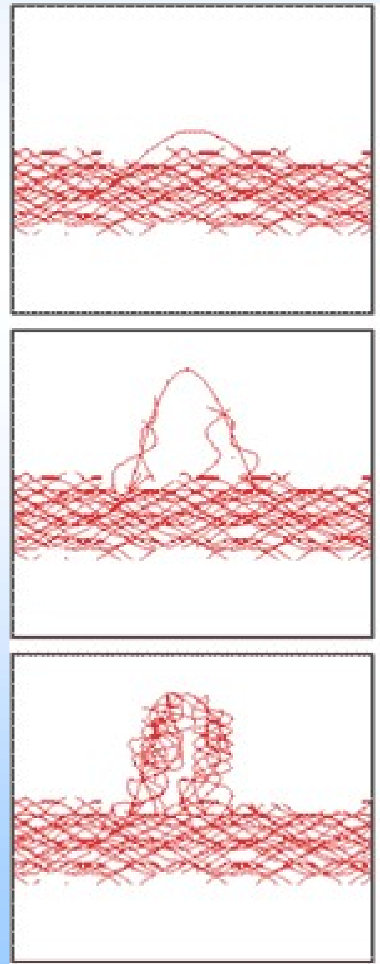
Fibre strength - fibres with lower strength are less likely to pilling

Fibre blend - in general, blends have a higher tendency to crease

wrinkling than 100% yarns

Staple length - longer fibers pilling less than short fibers

Twist - higher twist has a lower tendency to pilling



anti-pilling treatment on textiles

The use of PES fibres with reduced pilling obtained, for example, by modification of the fibre-forming polymer by partial replacement of terephthalic acid by isophthalic acid or 5-sulfoisophthalic acid.

by suppressing fibre migration in the yarn by suitable construction of the yarn and the surface formation. Fabrics densely constructed with coarser, sharply twisted yarns and panels made of endless or profiled fibres are less prone to pilling.

By perfecting the ironing and trimming to remove the protruding ends of the fibres which could become centres of pilling

Heat treatment / steaming and thermofixation / where the fibres become fixed and do not tend to migrate

anti-pilling treatment on textiles

The most effective and most commonly used method of stabilising fibre position in textiles is based on the application of film-forming agents with good bonding effects that prevent fibre migration. Reactive polyacrylates, which form a sufficiently stable elastic film on the surface of the fibres over a wide temperature range from - 30 to 100 °C, are particularly dominant in this respect. The formulations are most often applied by bath padding /40 - 80 g.l-1/ and drying at 130 °C.

Crosslinking of cellulose by reactants

Cross-linking of cellulose with reactants reduces the mutual displacement of their chains, thus improving fibre recovery and dimensional stability. At the same time, fibre stretch and flexibility and resistance to mechanical stress are reduced.

Depending on the moisture content of the treated material, we distinguish between crosslinking:

wet treatment (textile moisture content 60-80%) - non-iron treatment

dry (moisture content of the fabric 0,5-2 %) - non-wrinkle treatment

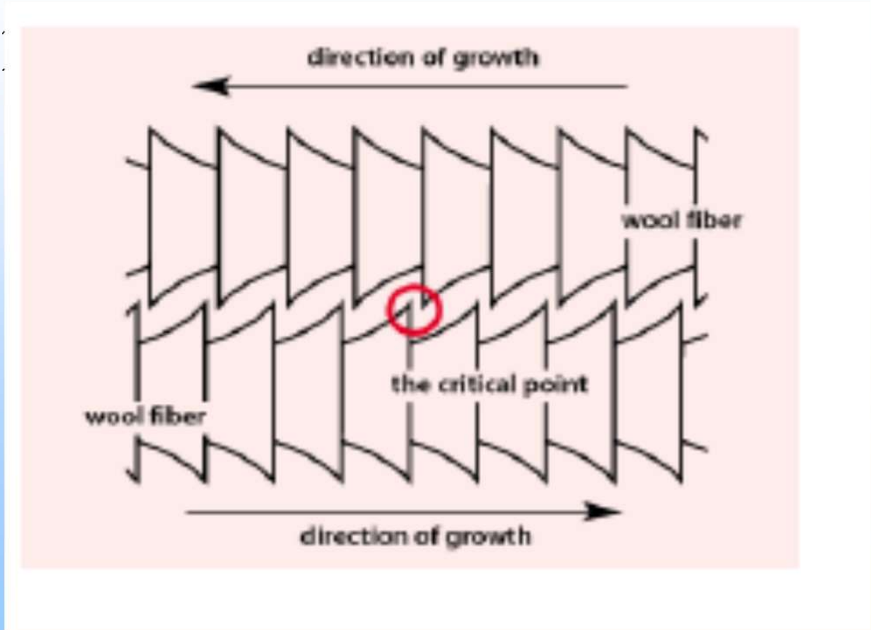
Permanent - press finish These modifications lend dimensional stability and shape memory to the finished products, e.g. stability of buds, folds, mitres, etc. It is a perfect non-wrinkle treatment of products ensuring easy maintenance in the home, i.e. washing and drying without ironing. The final operation, in which the product acquires stability and shape memory, is carried out after finishing.

Non-felting treatment of wool

If the wool fabric is mechanically damaged when wet

stressed, felting occurs.

This is caused by the flaky surface of the wool, because the fibres with their flakes dig into each other



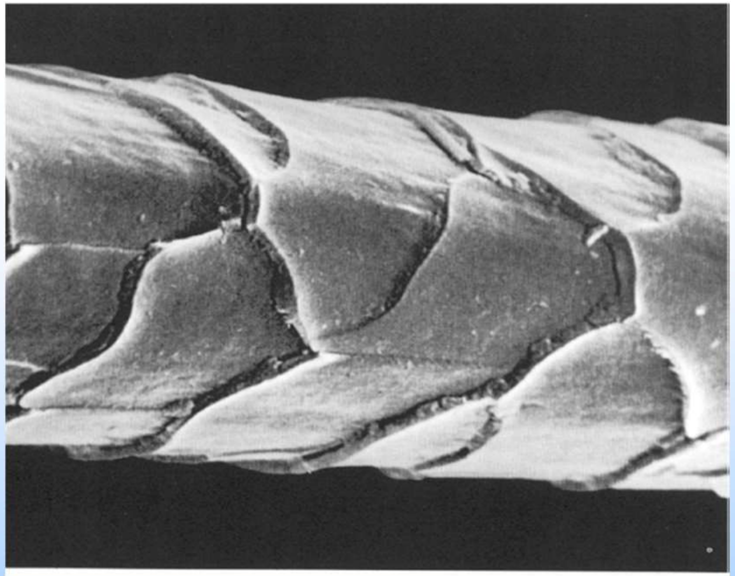
Non-felting treatment of wool

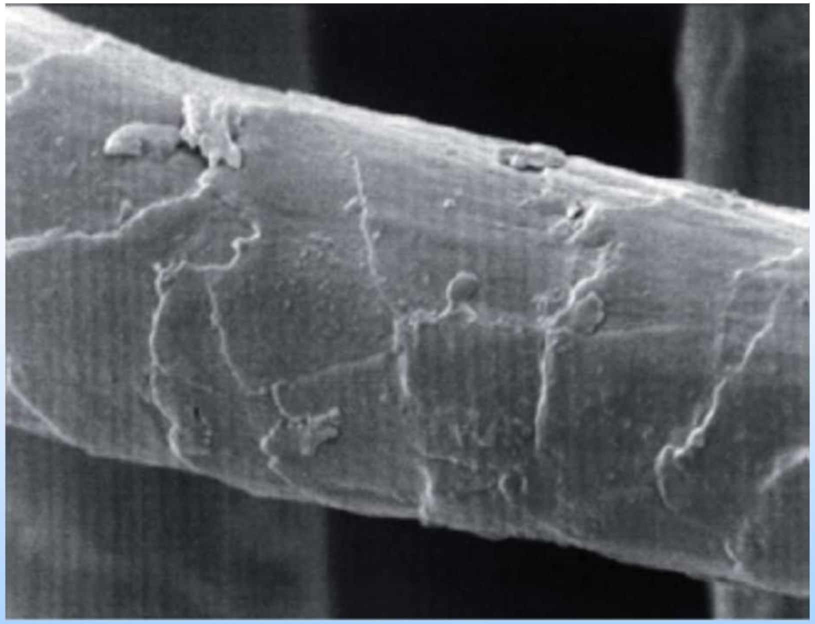
- In wet washing, which is accompanied by mechanical stress, without this treatment, felting gradually occurs, which is undesirable.
- Filling can be prevented to some extent:
- 1/ by the construction of the yarn or fabric - e.g. by high yarn twists,
- compact weave and greater finishing
- 2/ the addition of 40-60 % synthetic fibres

3/ by reducing the plasticity of the wool by creating stable transverse bonds
4/ reducing the coefficient of friction of wool fibres caused by their flake structure /breaking or masking of flakes/

Non-felting treatment of wool

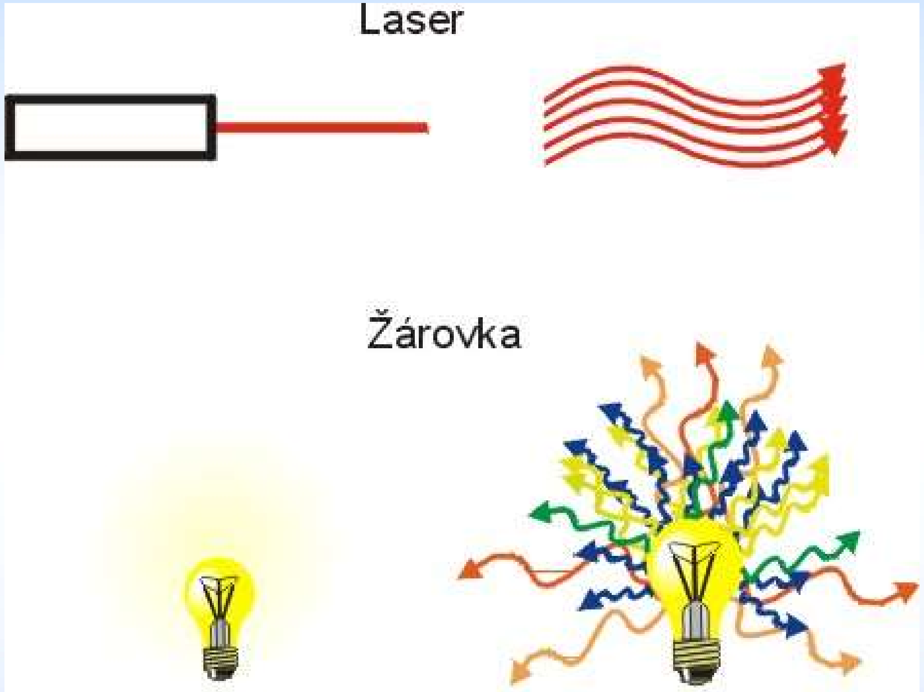
- Oxidation methods that do not use chlorine are based, for example, on the action of oxygen released from peroxosulfuric acid /H2SO5/, potassium permanganate or hydrogen peroxide.
- Chlorination methods are very economical. The cystine contained in the scales is converted by oxidation into cysteic acid, which is very soluble in water.

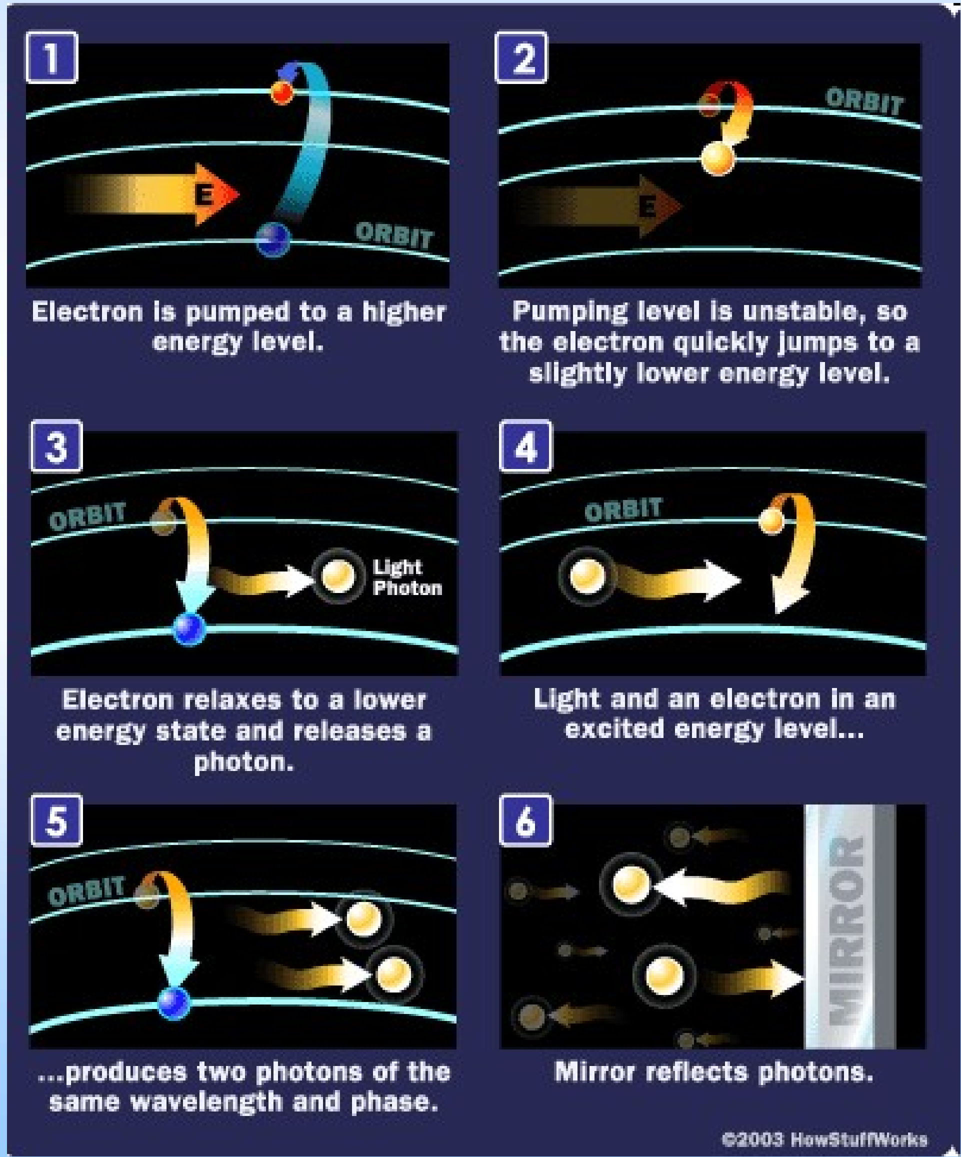




SEM snímek chlorované vlny

Laser

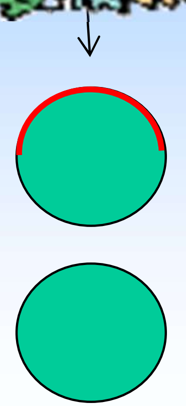




The radiation is monochromatic, polarized, space and time coherent, narrowly directional (minimum divergence) and has a high energy density.

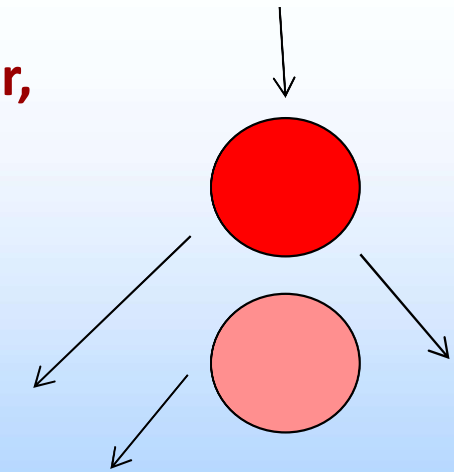
Laser

Light absorption:



Very high absorption - e.g. UV region around 250 nm, surface overheating, "craters" form - increase in surface roughness

2) Low absorption - e.g. IR at 10.6 micrometer, only thermal effect



CO2 laser

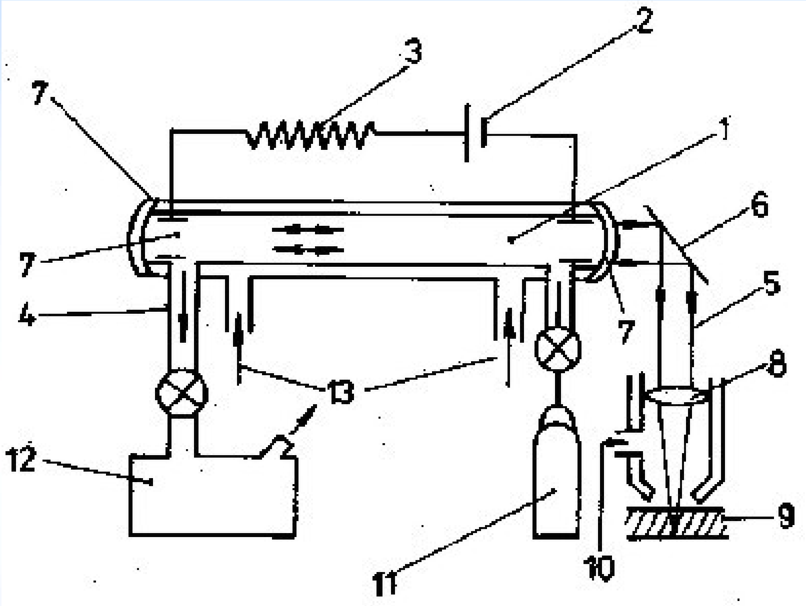
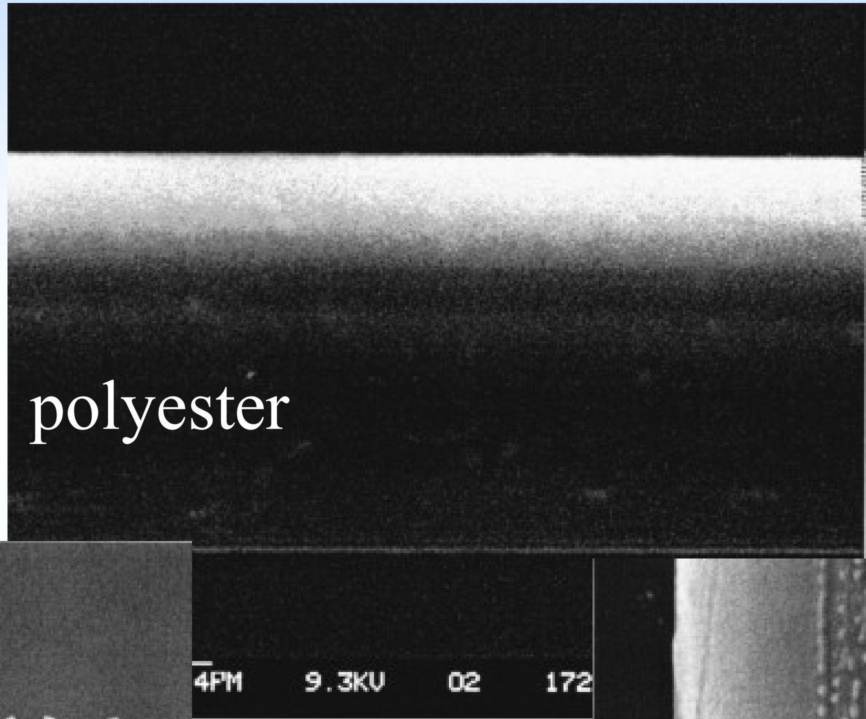
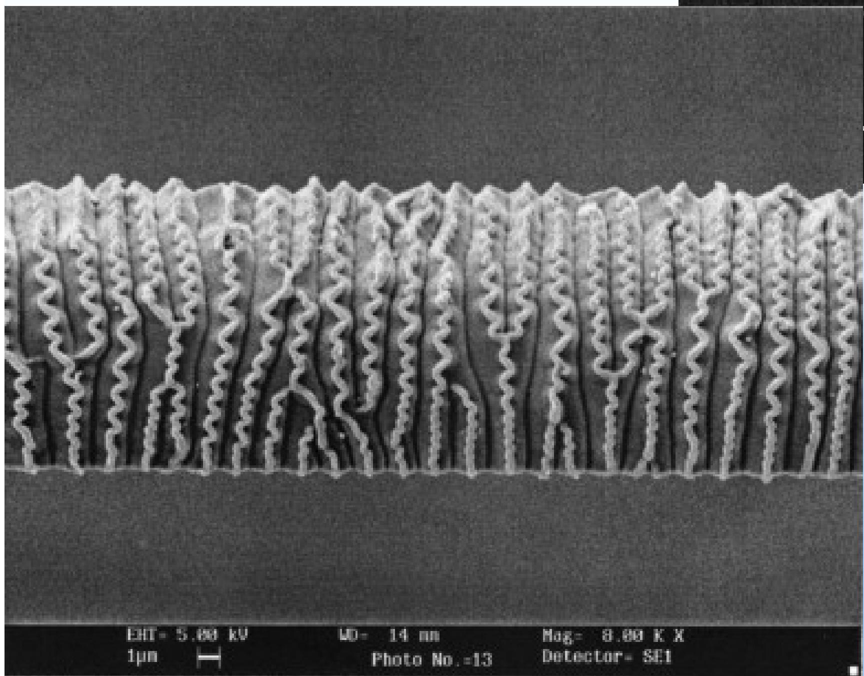


Diagram of CO_2 laser (1 - laser tube filled with gas, 2 - power source, 3 - damping resistance, 4 - gas flow, 5 - laser beam, 6 - mirror, 7 - semi-transparent mirror, 8 - lens, 9 - workpiece, 10 - exhaust gas, 11 - gas cylinder, 12 - exhaust pump, 13 - cooling water)

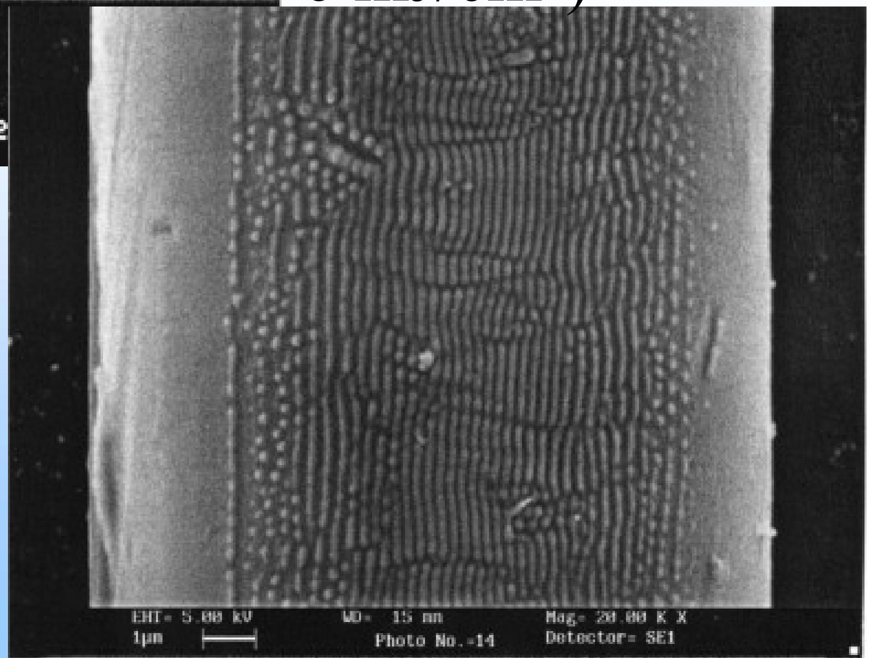
UV laser

polyester (5 x 100 mJ/cm^2)

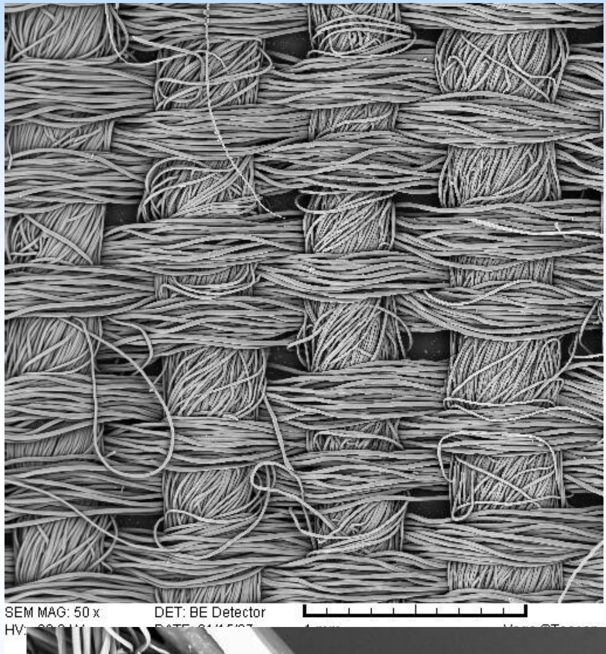




polyester (2000 6 mJ/cm^2)



CO2 laser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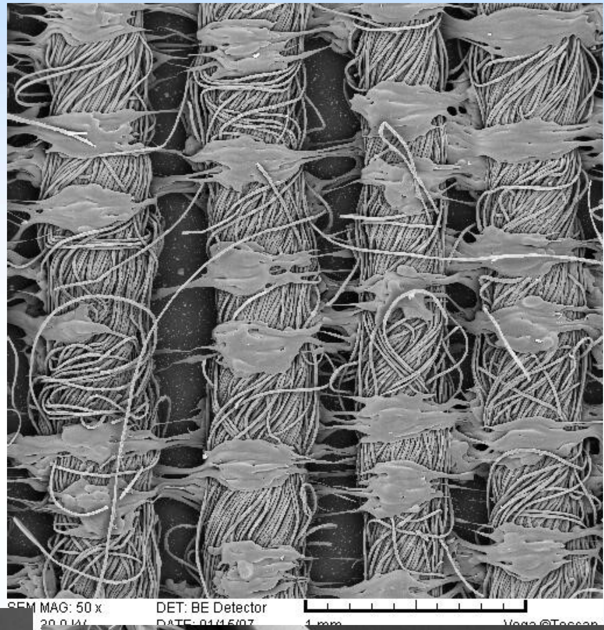
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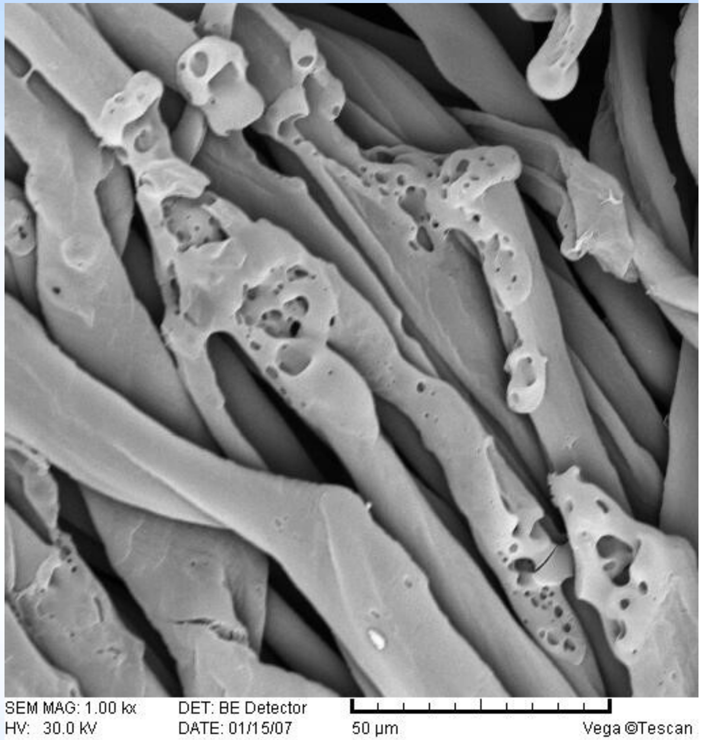
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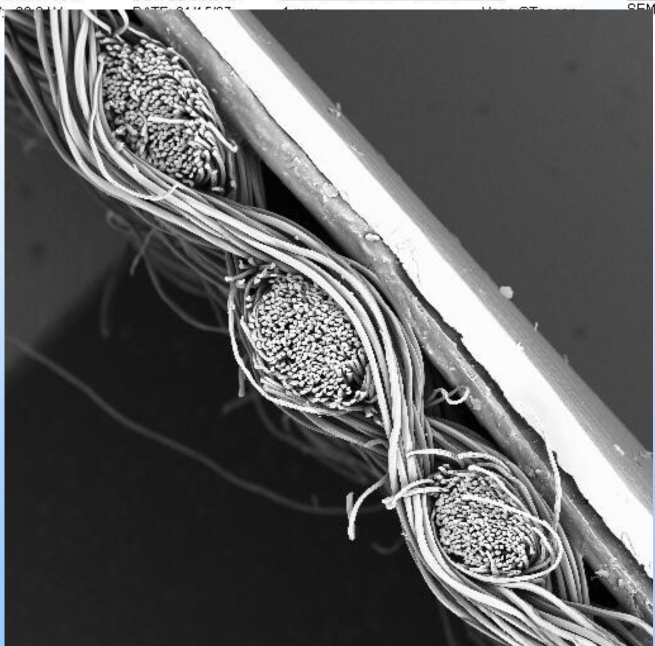
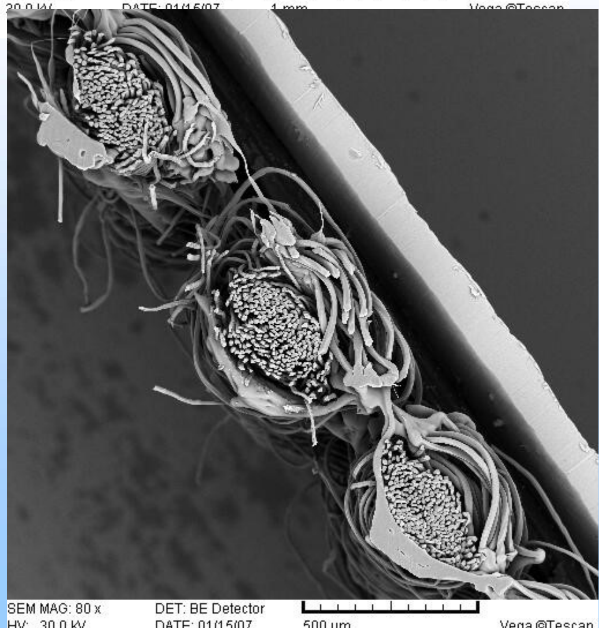
Vega ©Tescan

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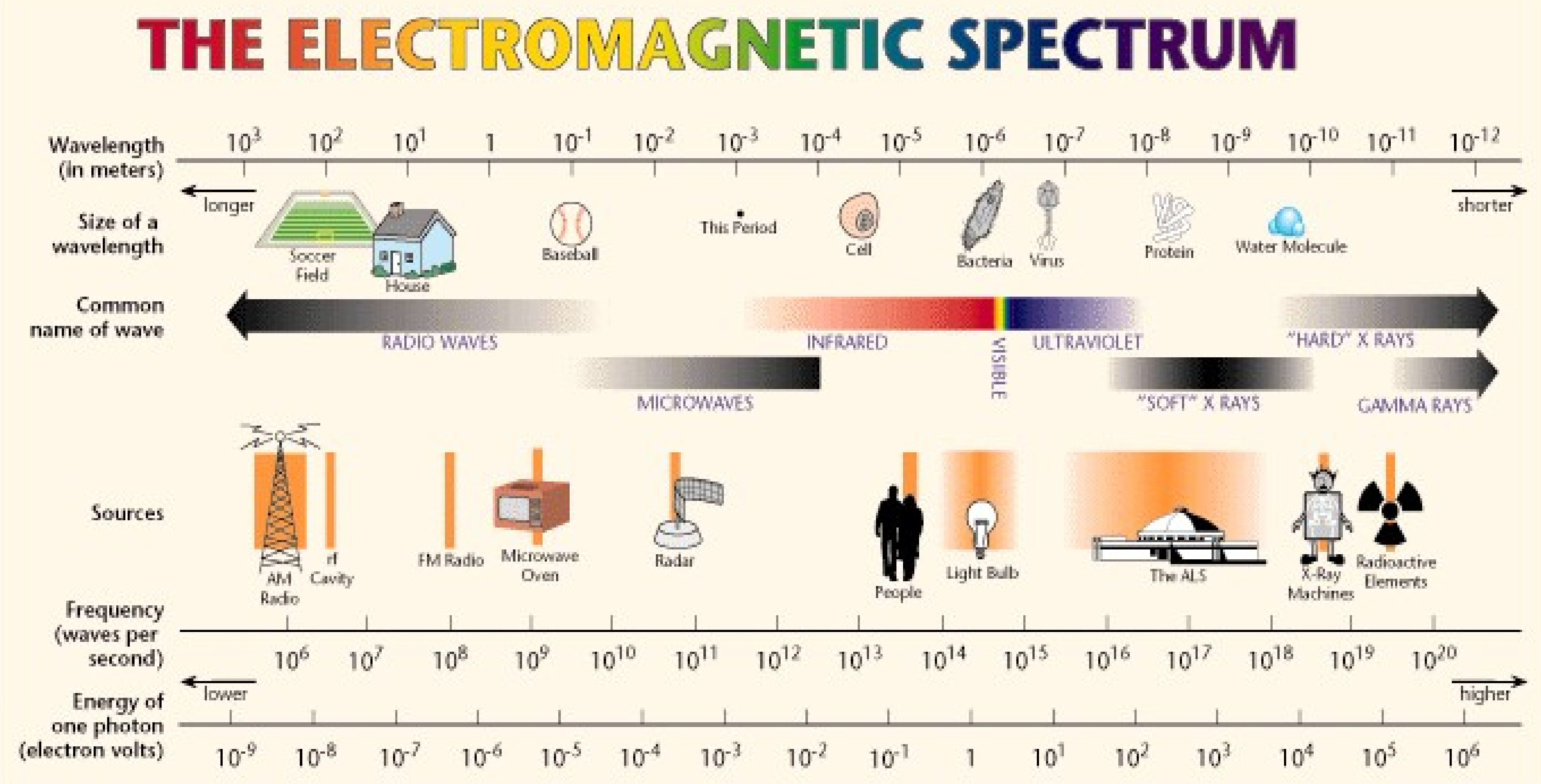
FAKULTA TEXTILNÍ

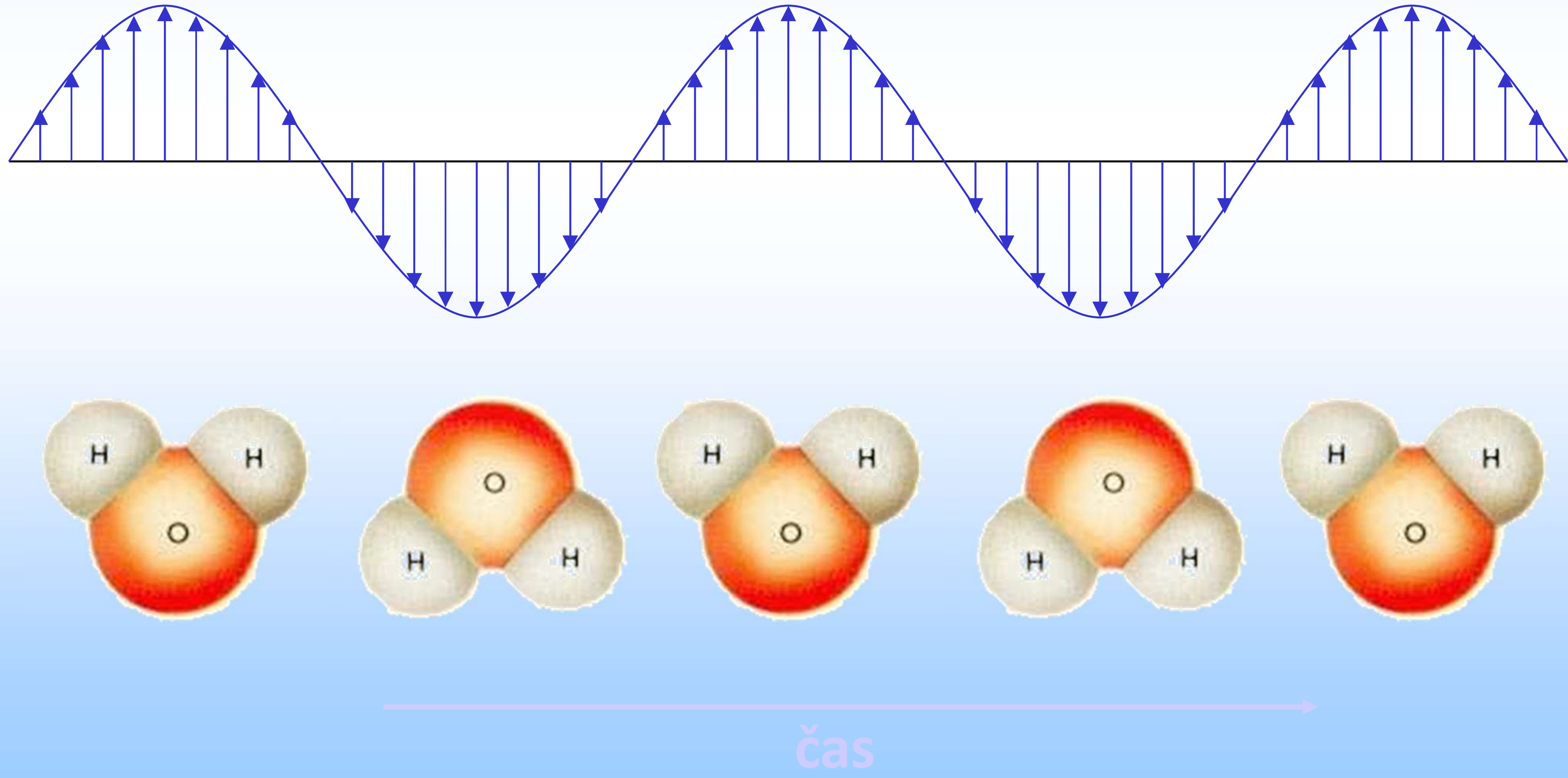
Electromagnetic waves

Microwaves - electromagnetic waves with frequency 300 MHz-300 GHz

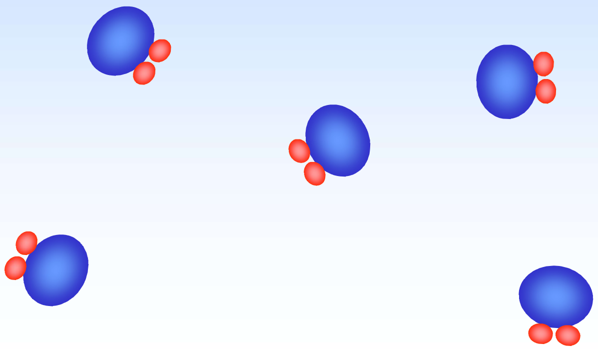


Microwaves and water

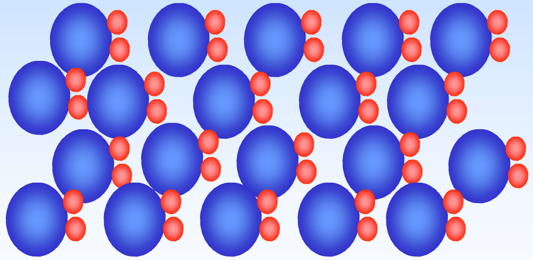
- Microwaves = time-varying electric field
- Polarity reversal = rotation of water molecules



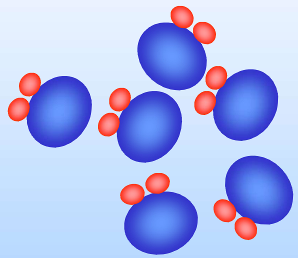
Microwaves and water



Páry – rotace molekul nezpůsobuje ohřev – molekuly jen volně rotují….

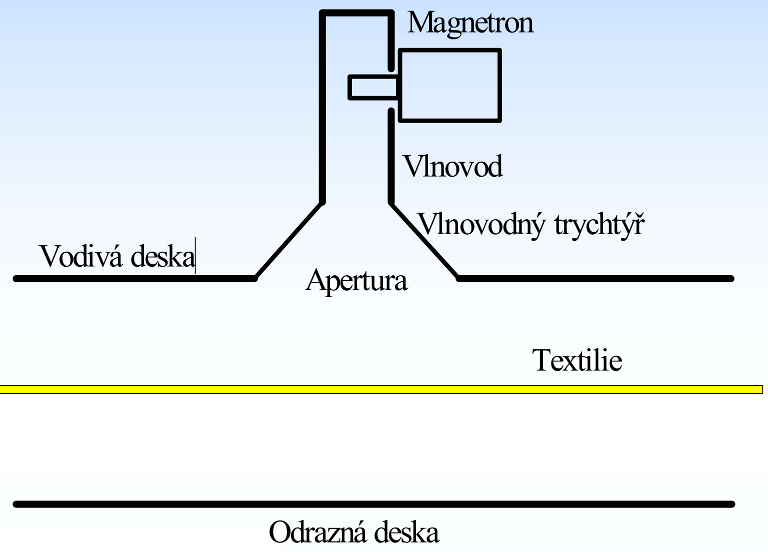


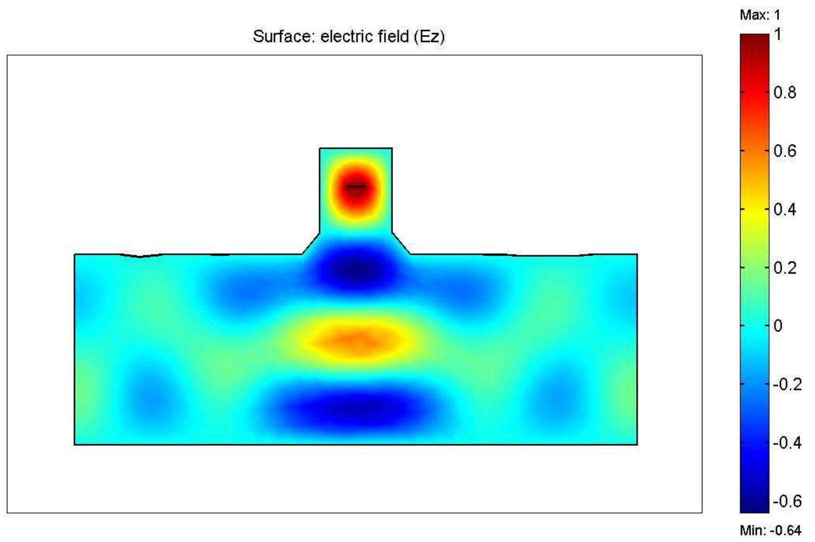
Pevná látka – molekuly jsou pevně spojené, nemohou rotovat a nedochází k ohřevu vlivem mikrovln

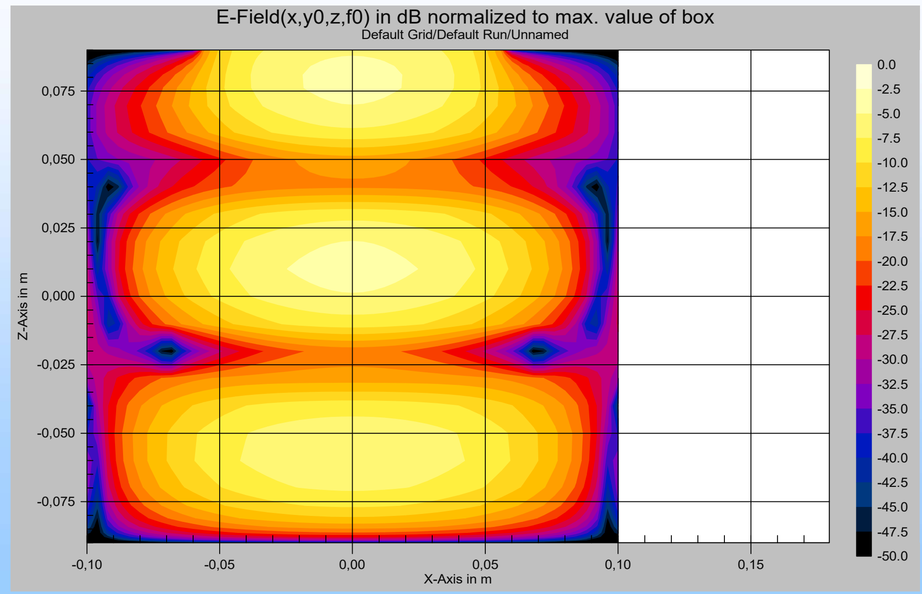


Kapalina – molekuly jsou volné, ale tak blízko, že rotace vyvolává tření (ohřev)

Microwaves and textile

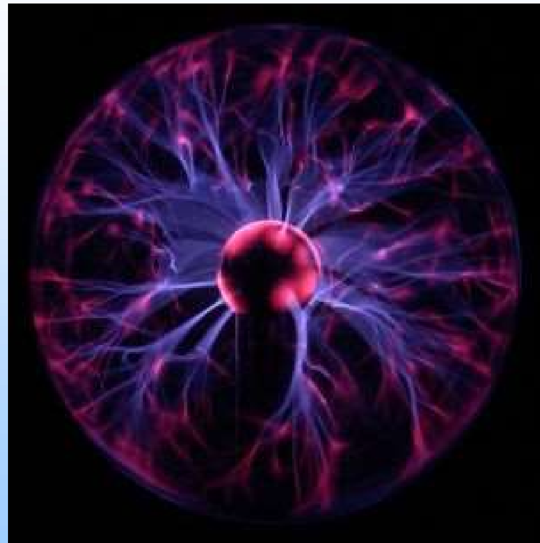






Plasma

Plazma



Plasma

The term plasma was first used in 1928 by Irwing Langmuir (1881-1957).

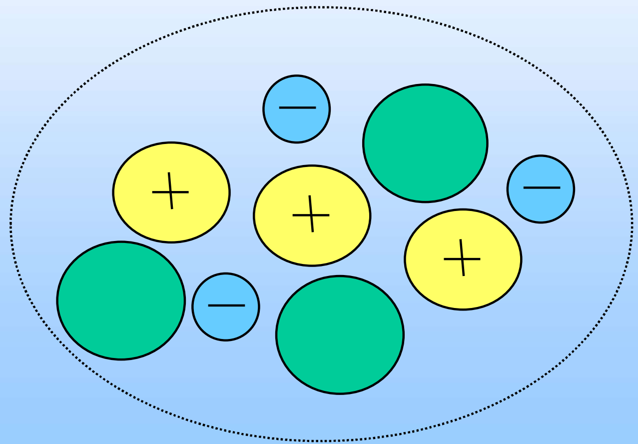
The definition of a plasma is: "A plasma is a quasi-neutral collection of particles with free charge carriers that exhibits collective behaviour." It is a partially or fully ionized gas that satisfies the additional conditions of collective behavior and quasi-neutrality.

Plasma

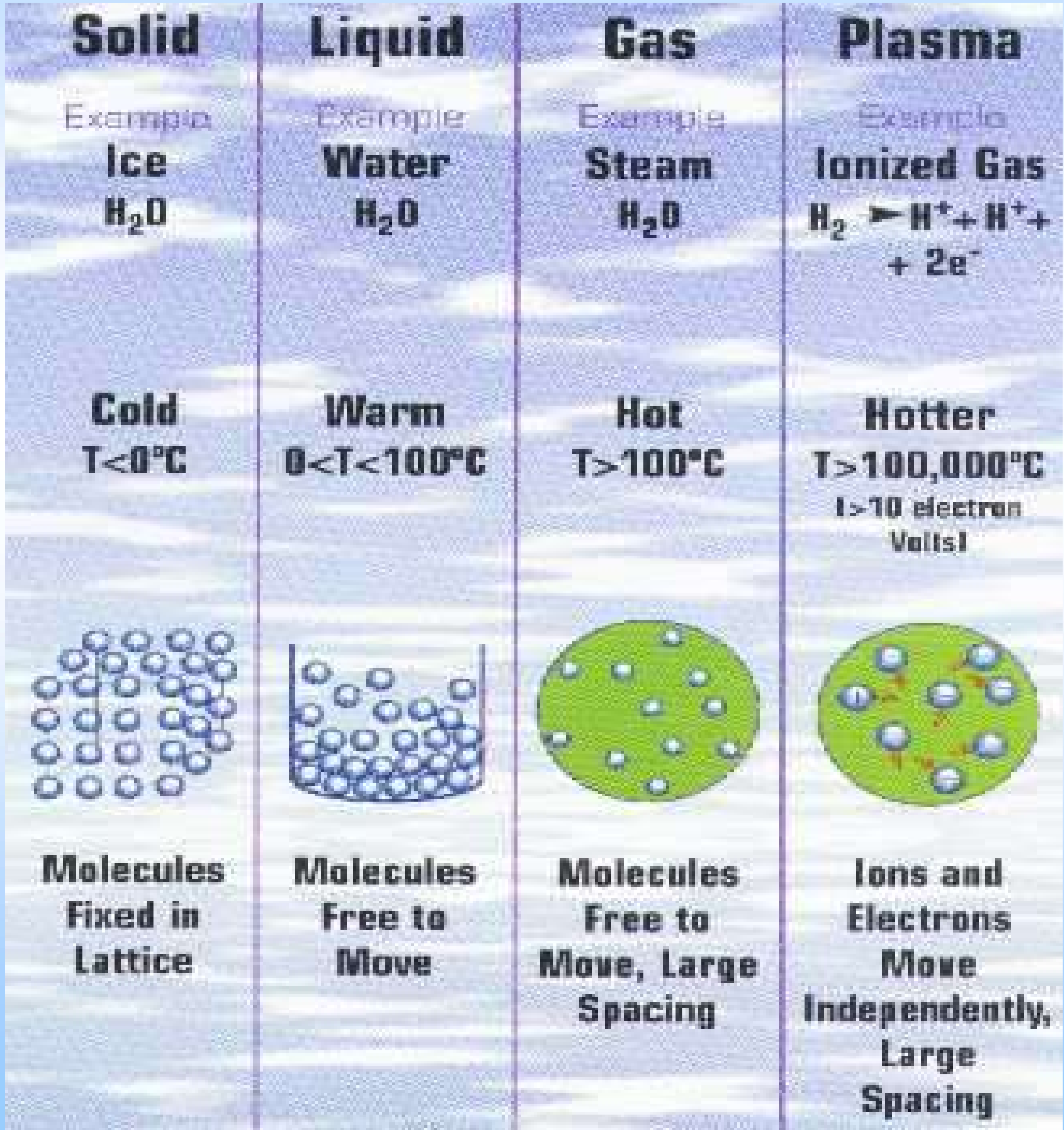
Quasi-Neutrality

A gas is quasineutral if the amount of free negative charge is approximately equal to the amount of positive charge. However, its charged particles can group together to form local charges that give rise to electric fields, yet the whole behaves externally as neutral. Mathematically, quasi-neutrality can be written as the equality of the summed concentrations of negative and positive particles.

$$\sum n_+ \cong \sum n_-$$



What is plasma?



- ✓ Called the fourth state of matter
- ✓ A partially or fully ionized gas

$$N_2 \leftrightarrow N_2^+ + e^-$$
$$Ar \leftrightarrow Ar^+ + e^-$$

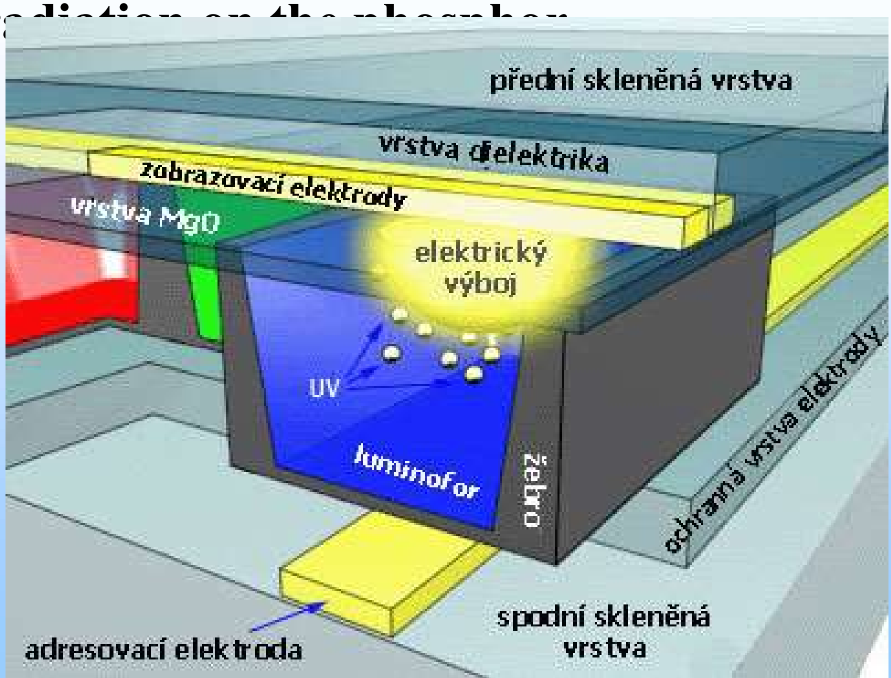
it is necessary to add energy for ionisation

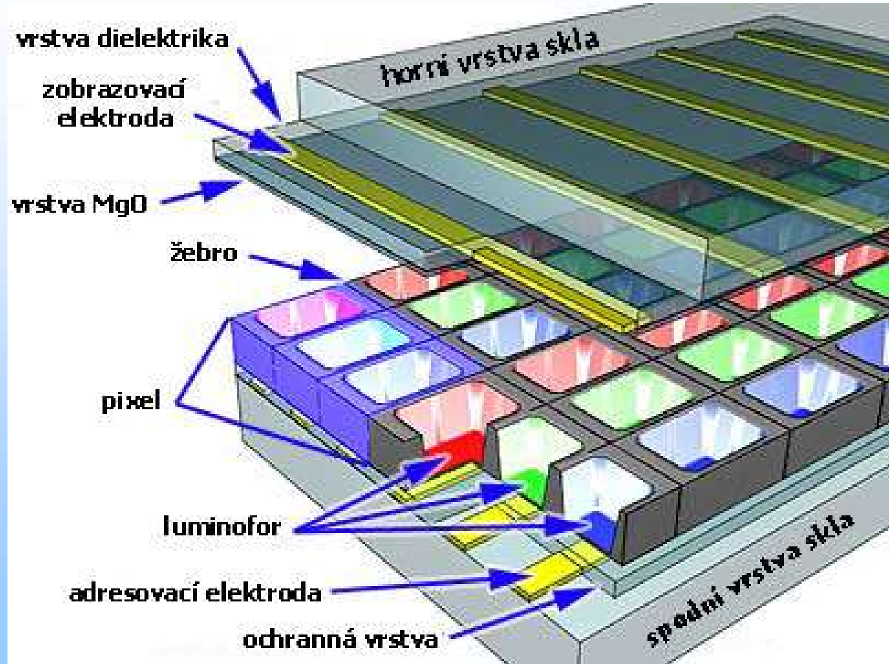
It is the most common form of matter, accounting for up to 99% of the observable universe.

Plasma in Display- TV

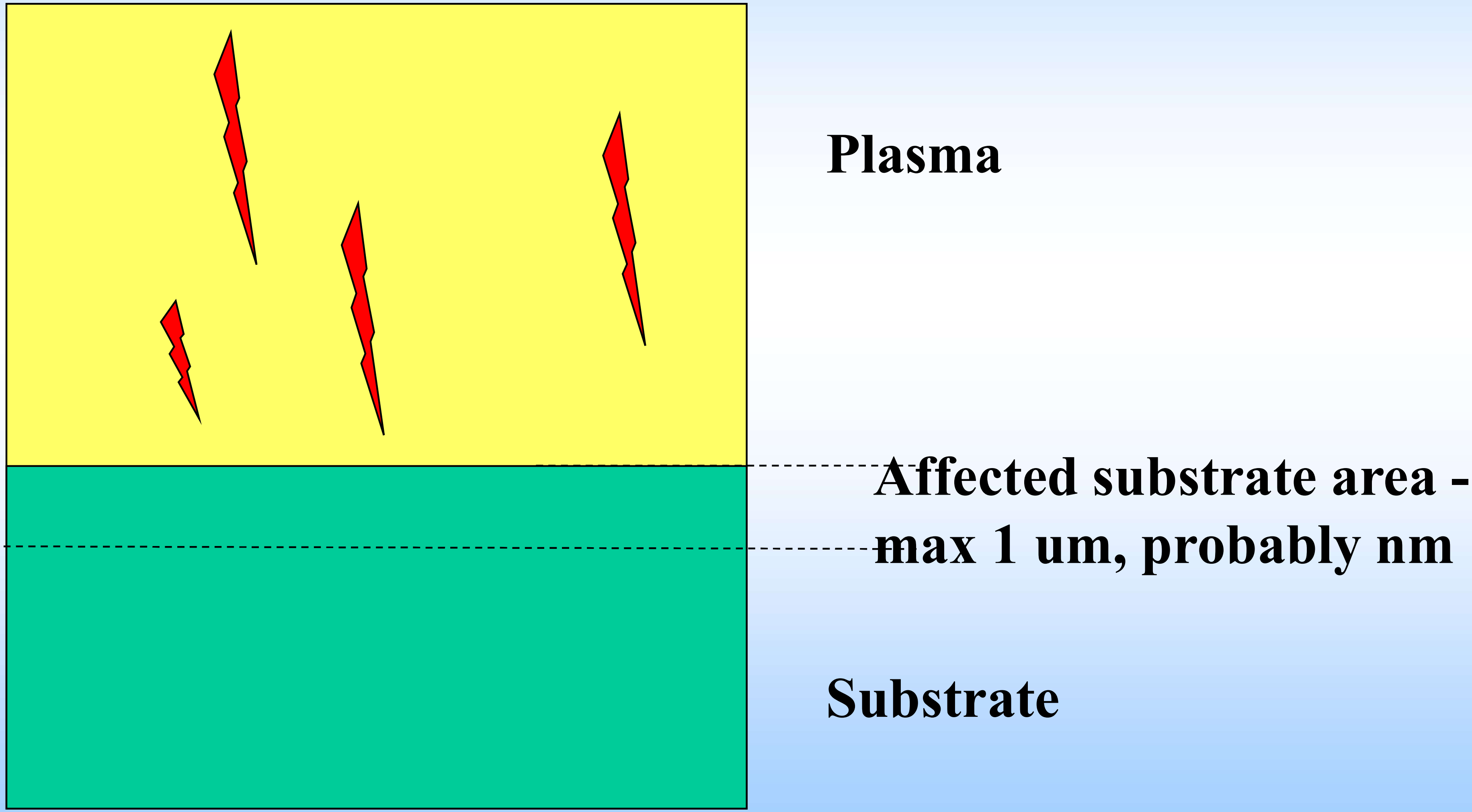
the image is composed of pixels and the pixel itself is further composed of three subpixels (RGB = Red, Green, Blue), each of which is filled with plasma, which is most often argon. Plasma televisions work on the principle of ionised gas.

The discharge produces UV radiation, which is subsequently converted to visible radiation on the phosphor.



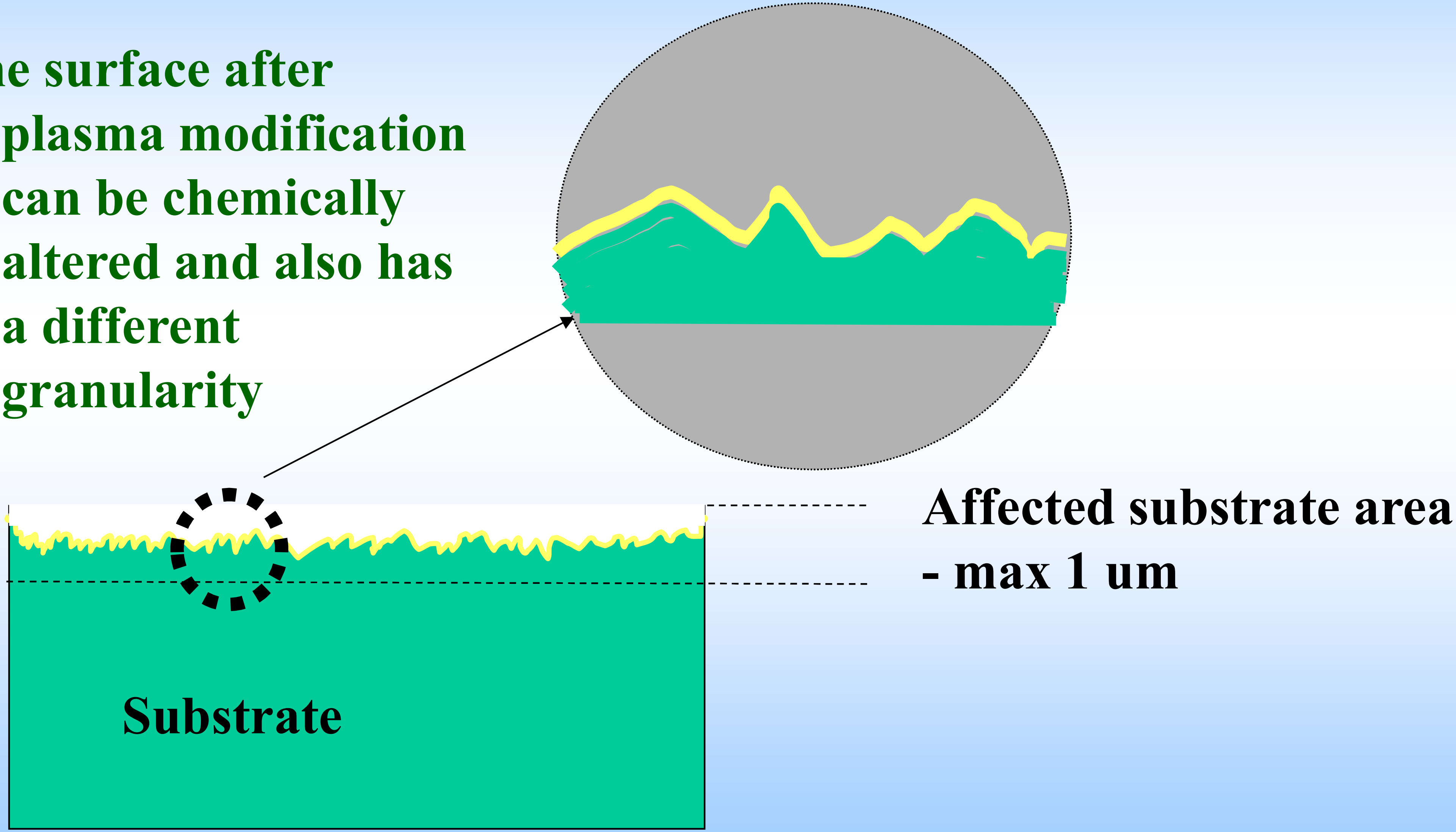


Plasma - Processes on the substrate

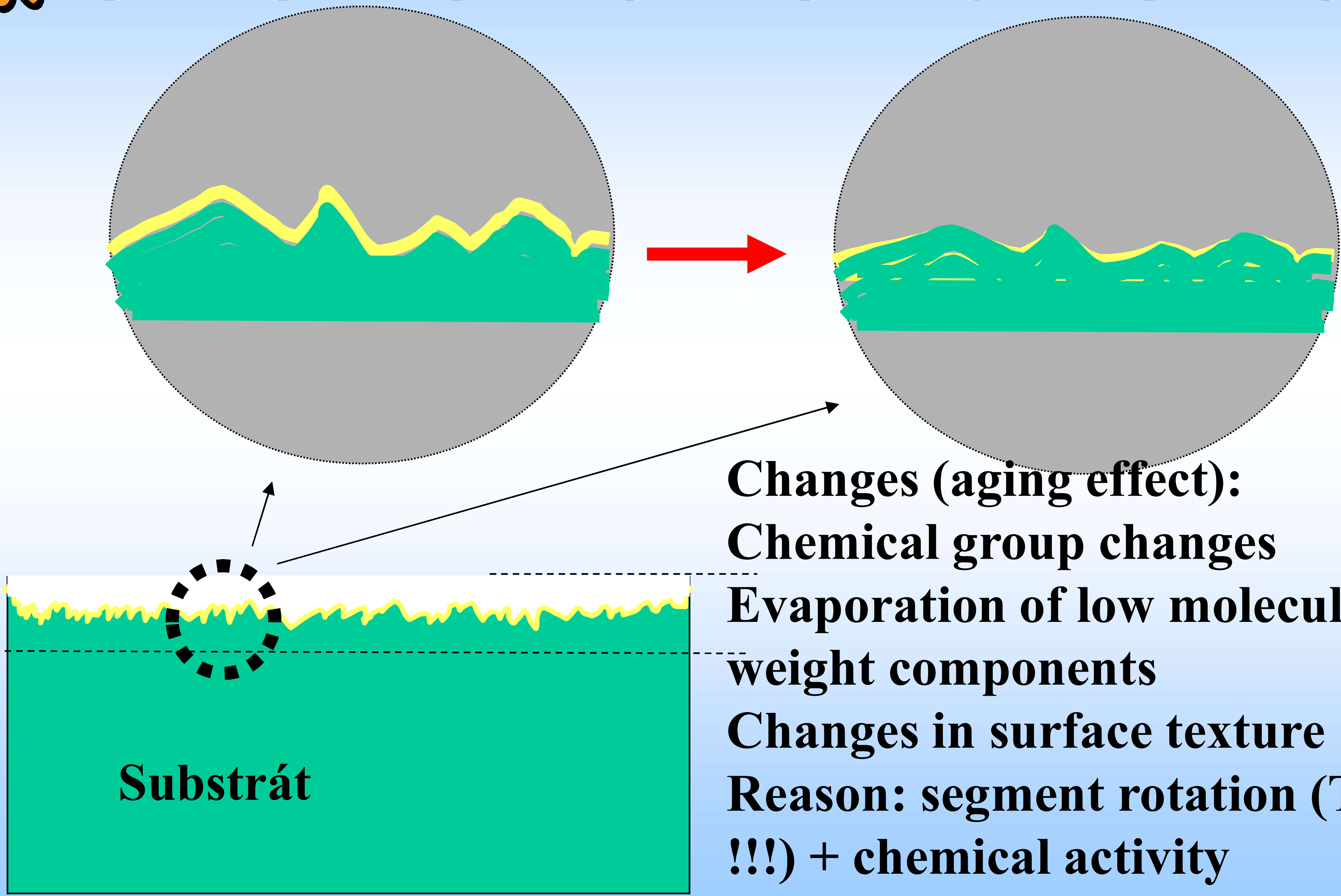


Plasma - Processes on the substrate

The surface after plasma modification can be chemically altered and also has a different granularity



Plasma - Processes on the substrate



Changes (aging effect):

Chemical group changes

Evaporation of low molecular weight components

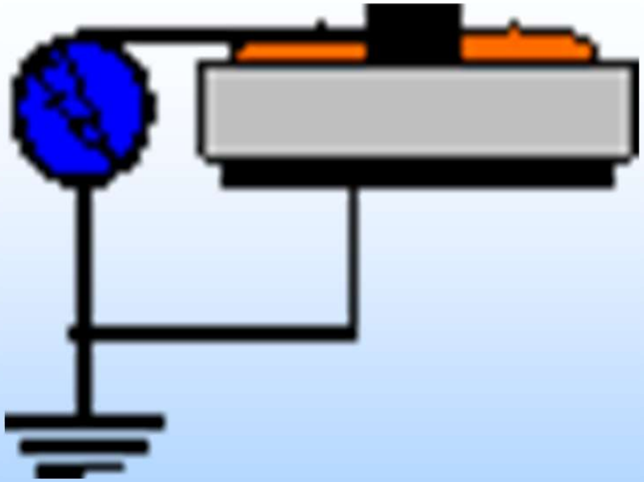
Changes in surface texture

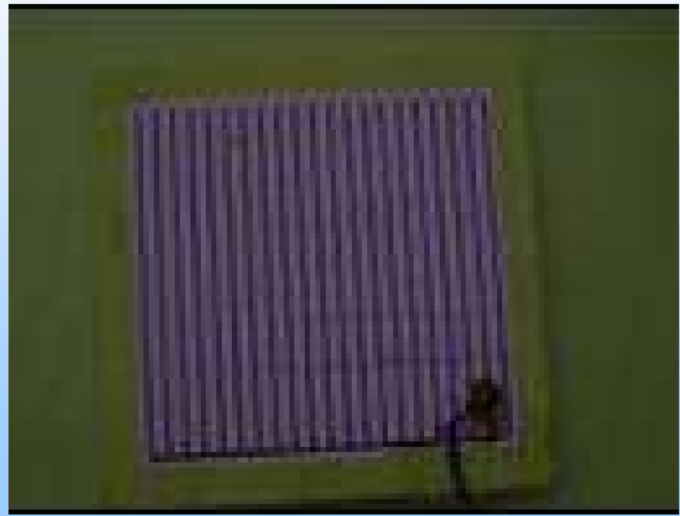
Reason: segment rotation (Tg !!!) + chemical activity

Plasma equipment

Universal plasma reactor 100W

- barrier discharge



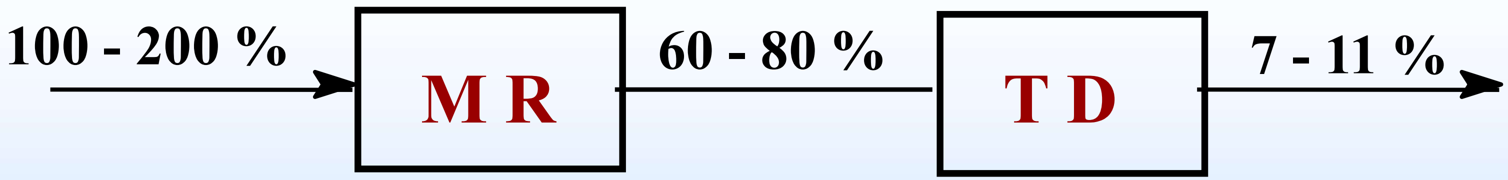


Wet finishing: DRYING TECHNOLOGY

To lower the moisture content in the textile material :

1. Mechanical water removing (MR)
2. Thermal drying (TD)

E.g. Process sequence for cotton drying

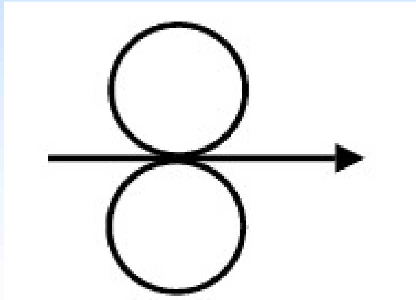


Mechanical drying is the more economical, costing less in terms of energy.

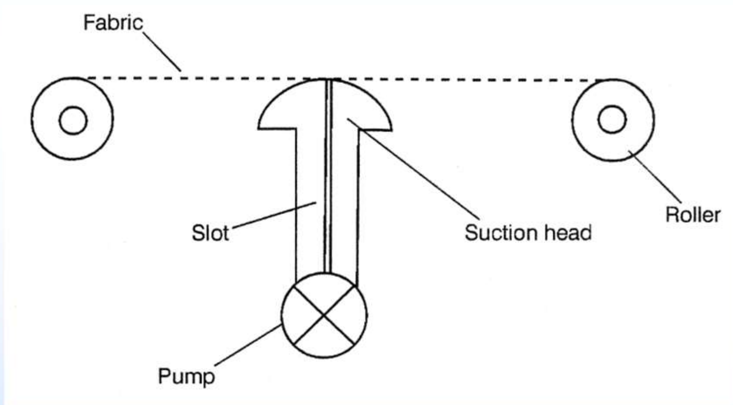
Thermal drying only until the fibre’s standard residual moisture content.

Wet finishing: DRYING TECHNOLOGY

Mechanical water removing methods



1) **Squeezing (mangling) – continuous process**



2) **Vacuum extraction – continuous process**

3) **Centrifugation – discontinuous process**

Perforated basket rotate at high speed (over 1000 rpm). Centrifugal force - forsing surplus water through the perforations.

Wet finishing: DRYING TECHNOLOGY

METHODS OF THERMAL DRYING

Methods of drying	Advantages	Disadvantages
Convection drying (hot air)	- Small risk of fabric thermal degradation - High flexibility in process regulation - Based on any source of energy	- Big energy consumption
Conduction (contact) drying (drums)	- Low energy consumption - Maintenance reduced to the minimum	- Very poor handle of the fabric - High time contact of the process regulation
Radiation drying Infra-red	-Very flexible regulation to the surface of fabric	- Risk of burning - Can be based only on gas and electricity.

Thank you for your attention!