Micro-perforation of running webs

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Material webs such as those used for cigarette-, mouthpiece tipping paper, filter-coated, special, bag or packing paper webs, bonded fabrics, spun bonded non-woven, technical textiles, fabrics, laminate, etc with base weights from 20 gsm to up to 150 gsm, up to 10 gsm LPDE coating films, are perforated electrostatically (ESP) by nano, micro, laser, mechanical micro or macro for different application purposes.

For clarification: Electrostatic (ESP) nano, micro-perforations are statistically irregularly distributed, varying by size by up to 40%, and analogically, under laser or micro-, macro-mechanical perforations, evenly arranged in diameters of about the same in size, at best non-inclined holes and rows of holes of varied arrangements.

Although invisible to the human eye, electrostatic – ESP – nano or micro-perforations may be arranged in areas or zones at specific distances within the web. The sizes of the holes can range from 1 to 100 microns in diameter and hole sequences from 1.5 to 16 million pores per second. Arrangements of pores in zones are usually produced in widths of 2–6 mm and at pore densities of 15–250 pores per sqcm, however the perforation of pores in areas produces pore densities of up to 2 million pores per m^2. ESP perforations allow for porosity levels from 80 to 2500 CU (Coresta Units ml/cm^2/min), up to 50 perforation zones across the web, web widths from 100 to 2000 mm at web speeds of up to 500 m/min, depending on the material porosity and consistency in relation to its ability to perforate (*figure 1, 2, 3* and *4*).

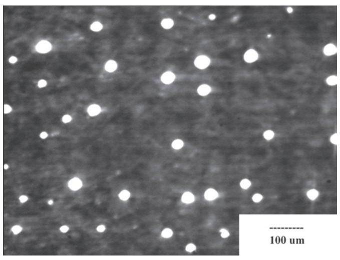
Laser perforation

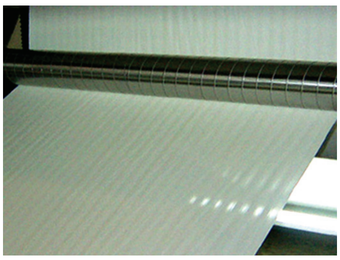
It is possible to perforate hole sizes of 60–200 micron at a hole density typically of 10–30 holes per cm length, hole sequences from 100.000 to 300.000 holes per second at a maximum of 16 punctured perforation rows by laser distributed over the width of the web with traditional systems or machines on the market using pulsed or enlarged and focussed laser beams. Porosity levels range from 100 to 3000 CU, normally with web widths from 100 to 300 mm at web speeds of up to 600 m/min, depending on the porosity and material consistency in relation to its ability to perforate (*figure 5, 6, 7* and *8*).

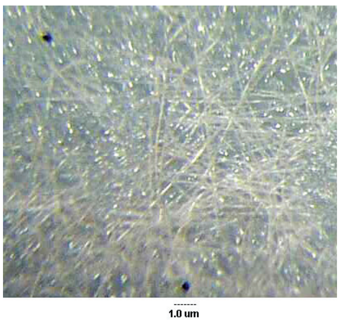
IPM is responsible for the development of the laser perforation technology *LPM-1* which is patent protected and operates with quadruple CO_2 laser beam inputs of up to 8 kW total optical power through to a dual jumbo beam multiplexer which can generate up to 200 individual laser perforation lines/rows across the web, combines automatic laser perforation head positioning, focus setting, web speeds up to 400 m/min, web widths up to 2000 mm, up to 4,000.000 holes per second, jumbo-roll-by-roll production, automatic perforation head positioning, optical online permeability and perforation line control, porosity feedback and other features. Each laser perforation line can range from 100 to 1000 CU.

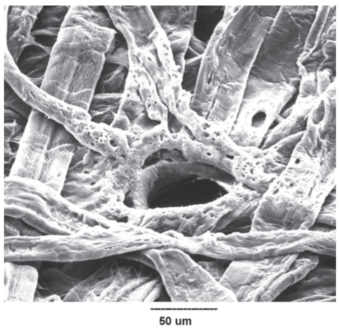
The concept of a dual jumbo laser beam multiplexer opens up many possibilities for use in other industry applications and processing such as cutting, cut-offs, welding, surface finishing, drilling, sharpening, polishing, forming, surface treatment, roughness improvement, etc. Each of the 200 single perforation heads can be positioned across the running web or static positioned material. The automated processes, equipment and devices open up completely new possibilities in industry, science, military or space laser application.

A new patent pending *Micro Laser Line* perforation technology *MLL-1* generates sinus waves, zigzags or other kinds of perforation designs as multiple pairs of micro laser lines in the web or material direction. This can be used for tipping cigarettes, packaging or other kind of paper webs. These special features of the micro laser line perforation technology enables fundamental new product characteristics to be achieved in perforation scripts, e.g. for mouthpieces with tipping paper on cigarette filters, product identification with visible





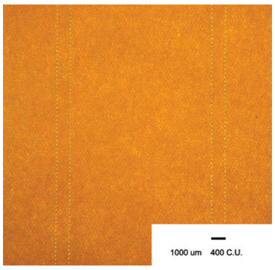


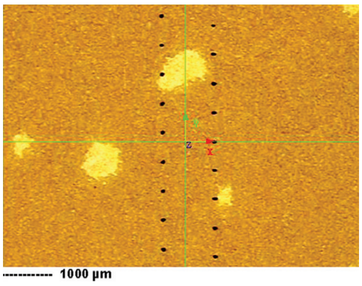


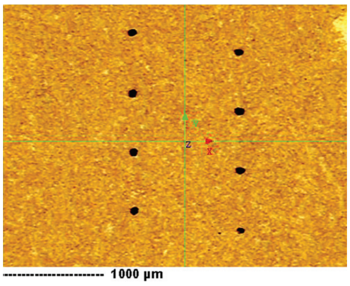
Top row (from left): Figure 1 and 2.

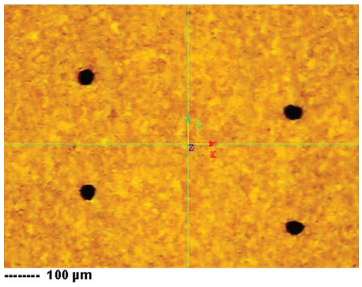
Bottom row (from left): Figure 3 and 4.

IPM (*International Perforation Management*). www.microperforation.com









From left:
Figure 5, 6, 7 and 8.

perforation holes as the brand name or company logo, anti counterfeiting designs, perforation cryptograms, etc. Also the process can be used in other material, industry and application fields (*figure 9*).

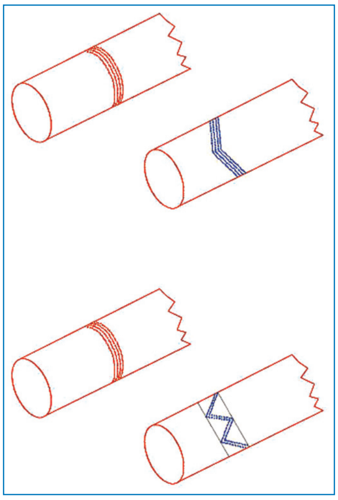
Controlled ventilation of filter cigarettes

Electrostatic perforation has been used for more then 25 years for ventilation of non-filter or filter cigarettes to create a direct and guided air bypass. For this purpose, cigarette paper for some non filter cigarettes and almost every kind of filter cigarettes and their tipping papers are electrostaticaly perforated offline by ESP in zones from 2.0–6.0 mm or with online or offline laser perforation rows in order to reduce the harmful substances such as nicotine and condensates to allowed values. Another effect is the possibility of guiding and controlling the ventilation degree of cigarettes.

New product properties with ESP nano sub-micro perforation

One of the most important concepts which can be applied to many applications and products containing bonded fabrics, bag or packaging papers, non-woven, etc with gas or steam permeability but water impermeability can be found at the application stage of the electrostatic nano micro-perforation technology.

This means that pore sizes from 0.2 up to 10 micron diameter by up to 5 million/m^2 are required. This is because of the greater surface tension of water which impedes permeation through the relatively small nano or micro pores. These and other physical advantages of the relatively small pores requires the application of the ESP perforation method because alternative perforation or processes would not be feasible, too expensive or simply uneconomical and would not lead to a successful application.



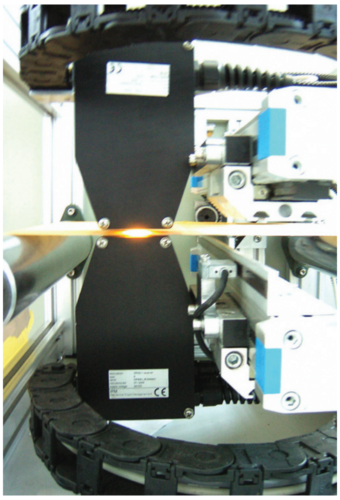


Figure 9 (left), figure 10 (right).

To meet the new ESP requirements, *IPM* has developed and patented electronic switching circuits which work as upward converters with IGBT (insulated-gate bipolar transistor), MOSFET (metal–oxide–semiconductor field-effect transistor) or HVFET (high-voltage field effect transistor) to produce power pulses from 1 up to 15 micro-seconds, high current peaks up to 300 Amps, base frequencies up to 200 kHz on ferrite transformers to generate up to 50 kVss at each sparking electrode.

Optical online permeability or porosity control

Since naturally porous web materials or web materials to be perforated are processed at speeds up to 600 m/min and web widths up to 2000 mm, using a pneumatic porosity measuring device, taking measurements whilst touching the web are very difficult. Further difficulties of this system include the disadvantages of increasing web tension, material abrasion, folding, leakage at the measuring head, impurities, nonlinear processing and calibration problems.

Thus, optical measurement techniques offer a better way for measuring the pneumatic static permeability of naturally porous or nano-, micro- or macro-perforated webs. The conditions mentioned above can be easily met by using optical porosity measuring technology thanks to the previously mentioned processing and online control, extremely small pore dimensions, relatively high track speeds and a high rate of repetition. Completely independent from the basic material information such as consistency, thickness, weight, colouring, formation, smoothness, brightness, opacity and other influences can be measured.

IPM has developed a number of new, patent pending, stationary and transverse optical measurement processes and systems which work with multiple colour sensors, precision line lasers, at scanning speeds from 20–200 mm/second,

porosity ranges from 80 up to 3000 CU, perforation line detection of 0.1 mm, nano micro holes from 0.5 up to 200 micron in diameter and up to 250 holes/cm^2 to determine data in real time. An internal sensor DSP controller unit determines each porosity level integrally in order to identify each perforation profile and their colour envelope curves.

Thus direct feedback into the perforation system makes it possible to compensate for any changes in porosity and perforation location so that each jumbo production roll up to 25,000 meters as well single or quadruple bobbin sets can be produced and quality controlled without intermediate stops and certificated for quantity and quality (*figure 10*).

Future prospects

The electrostatic ESP nano- or micro-perforation is usually used depending on the quality of fine paper, packaging webs, bonded fabrics, non-woven, filter paper, bag or force paper as well as special paper webs of most varied types. It is also used especially for additionally treating coarse materials when aiming for achieving special characteristics which for physical or process reasons cannot be achieved by other process technologies.

Our highly modern, industrially approved ESP perforation technology operating reliably 24/7 is able to be integrated into existing rewinding systems or other production processes or lines. Also, they can be used as completely independent perforation units. New ranges of applications will be made available as new products with special features are developed (*figure 11* and *12*). ■

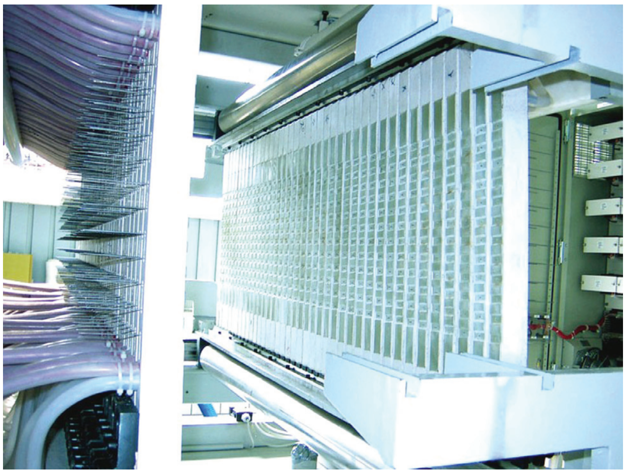


Figure 11 (left), figure 12 (right).