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New Subsurface Engraving Technique for High Resolution Marking of Glass

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Naginels (Non-Aggressive Glass Internal Engraving Laser System) is a patented technology allowing subsurface laser engraving of information in transparent materials without causing micro fractures, which might otherwise unacceptably weaken the glass structure and introduce the risk of glass rupture. Because micro-cracks are entirely prohibited in the chemical and pharmaceutical industry, the Naginels process is of paramount importance for these industries as a means of providing glass containers such as vials and syringes with secure tracking and tracing marks.

A consortium of six European businesses and two universities was established in 2004, in order to develop and commercialize the Naginels technology. Funding has been provided by the European Union's Sixth Framework Programme for the period 2002-2006 (see AN 2Vol. 12, No 2). The patent assignees are the companies Laser Engineering Applications and KS Techniques of Belgium, Amplitude Systèmes and Costet of France, Solos Identificazione E Protezione of Italy and UK based Total Brand Security and the inventors Axel Kupisiewicz of the University of Liège in Belgium and Eric Mottay of the University of Bordeaux in France.

In 2007, the Belgian company TrackInside was established to exploit the commercial potential of the technology in industrial environments.

Changes to Structure

Subsurface engraving involves focusing very short, extremely high energy laser pulses below the surface of transparent materials such as polymers, glasses, fused silica or quartz, thus locally changing the material structure in the focus of the laser beam. Obviously, such subsurface codes can neither be altered nor removed without causing considerable damage.

In the 1990s Q-switched Nd:YAG (neodymium-doped yttrium aluminium garnet) pulse laser engraving of transparent materials became possible by creating 50-100 μm sized light scattering cracks in the focus of a laser beam. Typical pulse durations are 100 nanoseconds (1 ns = 10^{-9} seconds), and these consist of a light beam as long as 30 meters.

Such relatively long pulses dissipate enough thermal energy to induce a significant rise in temperature inside the glass (>800°C), resulting in mechanical stress and subsequent local fractures of the glass (see Figure 1). This process allows, for instance, writing the well-known 3D images within glass cubes, which became popular gift gadgets. Apart from their weakening the glass structure, such images are written with relatively low speed and low resolution.

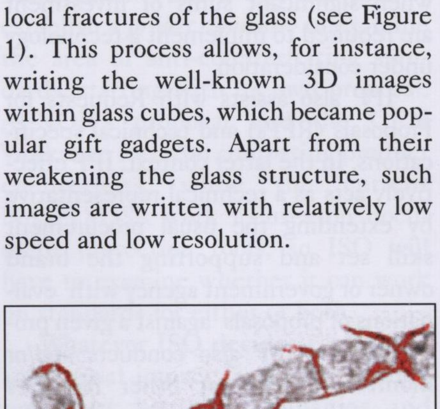

Figure 1 – Cracks in glass (marked in red) developed about dots written with a Nd:Yag laser generating pulses in the nanosecond realm. Source: VanRenesse Consulting (Netherlands).

No Micro-Cracks

Recently diode pumped Ytterbium doped pulse lasers have become commercially available from Naginels' partner Amplitude Systems (France) with typical pulse durations of 100 femtoseconds (1 fs = 10^{-15} seconds), forming light pulses of only 30 microns long. During this extremely short pulse the energy dissipated cannot be transferred to the surrounding material and this makes the writing process essentially athermal. Therefore, these ultrafast laser pulses do not induce micro-cracks but only locally change the refractive index of the glass.

Apart from engraving transparent materials, the exceptionally high pulse peak power allows the processing of almost all materials, from drilling holes in metals, performing eye surgery or painless treatment of teeth.

Diffractive Gratings

Furthermore, the high resolution writing process allows the creation of codes consisting of diffractive gratings up to 500 lines per millimetre. Such diffractive codes are only visible at specific illumination and viewing angles and require dedicated but low cost optical reading configurations. These optical properties render additional security against counterfeiting. Examples of diffractive alphanumerical and datamatrix codes and are given in Figures 2 and 3.

Advantageously, the pulse frequency of these femtosecond lasers is in the order of 1 MHz, allowing writing speeds sufficiently fast for industrial production. Marking speeds of up to 100 individual codes per second have been shown feasible. Laser written markings can be logos, alphanumeric texts, bar codes, 2D matrix codes such as DataMatrix, and special antifraud codes such as Kezzler codes

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Figure 2 – Glass object with 0.5 x 0.5 mm diffractive engraved mark (left) and a detail with 3.5 micron high alphanumerics (right). Source: Total Brand Security (UK).

or a combination of these.

Invisible Codes

The image resolution is high enough to allow codes to be written small enough to be invisible. For instance, microscopic 16 x 16 datamatrix codes, as small as 60 x 60 microns, can be written within 50 milliseconds. Visible 0.4 x 0.4 mm datamatrix codes can be written within 0.2 seconds.

Datamatrix codes allow very fast reading on the production line using commercially available readers, while in the marketplace handheld readers can be used. Additional alphanumeric codes can be made available for the consumer to check if a product is genuine by validating the code via the internet. The security codes will be provided by Kezzler of Norway.

Wide Range of Applications

Apart from the importance of this writing process in the chemical and pharmaceutical industry, its significance for other industries must be mentioned. Engraved bottles of wines or spirits and reinforced automobile windshields must withstand tough transportation constraints (temperature variations, vibration and shocks) and any micro-crack may cause crack growth and subsequent shattering of the glass product. Additionally, plastic products such as CDs and DVDs could be marked and/or coded in their transparent parts or in their plastic packaging, in order to guarantee the genuineness of the product.

Adrian Simmons, managing director of Naginels' founding member Total Brand Security, told Authentication News that the TrackInside process is currently in the first phase of its launch. Although no commercial applications are yet in production, the first commercial pilot projects are now running. The main market is the pharmaceutical industry (vials & syringes). Which companies are currently involved is still confidential, but Simmons noted that they all comprise key pharmaceutical suppliers and pharmaceutical companies. The market size could amount as many as tens of billions of markings per year for one company alone.

Contact: http://trackinside.net/; http://www.totalbrandsecurity.com/about-us.php; http://www.naginels.com/

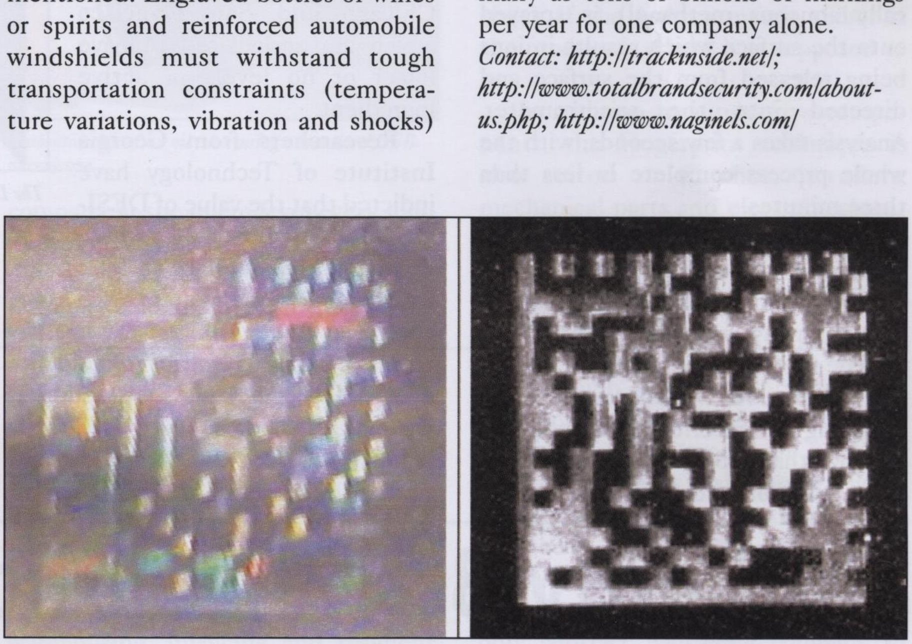

Figure 3 – 0.5 x 0,5 mm engraved 16 x 16 data matrix: diffracted light (left) and scattered light against a dark background (right). Source: Total Brand Security (UK).