	Deliverable No 8.7	Final Activity Report – Section 1	
Proposal Number	512931	Proposal Acronym	NAGINELS



Horizontal Research Activities involving SMEs Co-operative Research

Proposal/Contract No: 512931
 Project acronym: NAGINELS
 Project full title: Non AGgressive INternal Engraving Laser System

Start date of project: 1st October 2004 **Duration:** 25 months

Contract for:


CO-OPERATIVE RESEARCH PROJECT
Integrating and strengthening the ERA

DELIVERABLE 8.7: FINAL ACTIVITY REPORT **SECTION 1 – PROJECT OBJECTIVES AND MAJOR ACHIEVEMENTS**

Due date of deliverable 15th November 2005
Actual submission date: 30th January 2005


Organisation name of lead contractor for this deliverable: KS Techniques

Deliverable 8.7	Date	Version
Preparation	1/12/2006	1.0
Final	14/01/2007	1.1

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I PROJECT OBJECTIVES

I.1 *Scientific objectives*

The main objective of the present project is to validate that a new Femto laser technology (with short pulse duration and high repetition rate) can be made cheap and reliable enough to be embedded in a control process applied to decoration, antifraud and normative marking end-uses. This control system must lead to acceptable process stability and dependability performances.

This overall objective is split into five separate sub-objectives:

- O1: To validate that the Femto laser technology can generate codes with ultra-short pulses and be controlled in order to be implemented in the glass manufacturing industry (antifraud, normative marking) with sufficient stability properties
- O2: To validate that the Femto laser technology can generate ultra-short pulses and novel decorations, at repetition rates compatible with process productivity targets of the decoration industry (say one decorated bottle in less than 5 seconds)
- O3: To validate antifraud and normative marking applications which involve low cost recognition systems coupled with Femto laser markings
- O4: To measure decoration rates of pieces of glass using 3-D in depth engravings based on Femto lasers
- O5: To provide the SME contractors with the full system cost of ownership targets which will have to be met during the industrialisation steps of the technology

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1.2 Wider societal and policy objectives


The present project will contribute to wider societal and policy objectives. Indeed:

- The NAGINELS project will contribute in the struggle against fraud which is a major force behind the expansion of organised crime, tends to undermine public morality has considerable implications for employment, health, safety and encourages corruption at many levels.
- The absence of any harmful chemicals in the surface processing makes the NAGINELS process much cleaner and environment friendly.
- The NAGINELS process contributes to sustainable development. The femtosecond laser will be much more stable and reproducible, which in turn leads to less scrap or rework. Moreover the laser process does not use any specific chemicals as in surface engraving, which allows possible recycling of the glass bottles.

1.3 Target results

The target results, challenge of this project are summarised below:

	Qualitative	Quantitative
New Femto laser for the three applications	Industrial, high reliable, low cost	4000 working hours per year, with only one yearly maintenance shut-down
New internal engraving process	Does not fragilize the materials, is not alterable, high quality, low dependence upon the quality material	No micro cracks measured, no samples broken after hard stress (cold/hot & vibrations) simulations
Decoration	New colours or new type of designs based on refractive index change	10 ⁵ "pixels" engraved in less than 5 seconds for a cost of 0.5 Euros
Antifraud	Minimal size of the signature (100 micron datamatrix or special codes)	A code is engraved in less than 0.10 seconds with sufficient data (10 ¹⁰ references or 6 alphanumeric data's)
Normative marking	High contrast with high information number (datamatrix and bar codes) for 100 % control	An easily readable code is engraved in less than 0.50 seconds with sufficient data (10 ¹⁶ references or 10 alphanumeric data's)

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II MAJOR ACHIEVEMENTS

II.1 Validation & results


A first validation phase (WP1) was completed during the first year. During 7 months, we have made tests and analyses (see details in deliverables 1.1 – 1.2 -1.3 -1.4 and in Chapter of Deliverable 8.1 section2) to develop and validate the new process.

Initial target	Qualitative	Quantitative
New internal engraving process	Does not fragilize the materials, is not alterable, high quality, low dependence upon the quality material	No micro cracks measured, no samples broken after hard stress (cold/hot & vibrations) simulations

Results of the new process:

- ü does not fragilize the materials
- ü is not alterable
- ü is high quality (high accuracy (a few µm))
- ü less dependence upon quality material than CO2 and YAG laser
- ü no microcracks measured
- ü no samples broken after hard stress simulation

After the development of the new laser, new vision system and control/command system, two validations phases have been completed (WP4 & WP6) (see details in deliverables 4.1 – 6.1, 6.2 and in Deliverable 8.7 section2). The results are very good and we met all the targets defined in the beginning of the project for normative and anticounterfeiting applications. For decorative application, process is too slow (or too expensive).

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II.1.1 For anticounterfeiting applications:

Initial target	Qualitative	Quantitative
Antifraud	Minimal size of the signature (100 micron datamatrix or special codes)	A code is engraved in less than 0.10 seconds with sufficient data (10^{10} references or 6 alphanumeric data's)

Results of the new process:

- ü minimal size of the signature 60µm (datamatrix 14 x 14)
- ü more information than expected 10^{16} references or 10 alphanumeric data's
- ü process time (0,1s) (0,2 x 0,2mm – 14x14)

II.1.2 For normative applications:

	Qualitative	Quantitative
Normative marking	High contrast with high information number (datamatrix and bar codes) for 100 % control	An easily readable code is engraved in less than 0.50 seconds with sufficient data (10^{16} references or 10 alphanumeric data's)

Results of the new process:


- ü Better contrast than expected (grade A – AIM) – better than 72%
- ü more information than expected 10^{60} references or 43 alphanumeric data's
- ü process time (0,5s) (0,5 x 0,5mm – 20x20)

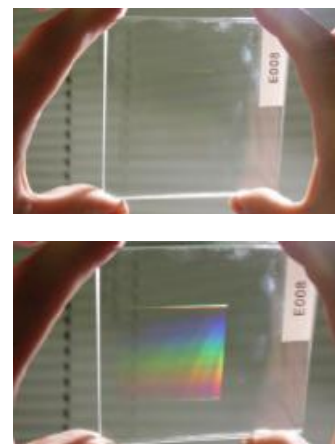
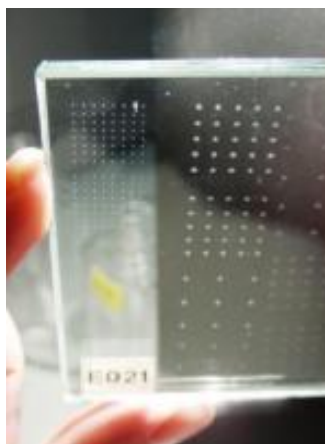
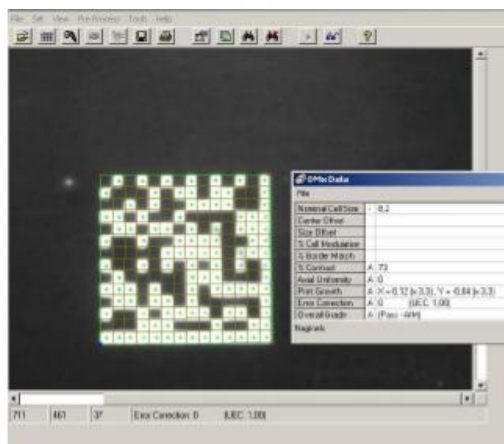
II.1.3 For decorative applications:

	Qualitative	Quantitative
Decoration	New colours or new type of designs based on refractive index change	10^5 "pixels" engraved in less than 5 seconds for a cost of 0.5 Euros

Results of the new process:

- ü New colour and surprising effect thanks to diffractive structures
- ü 5 x 105 pixels in less than 5 seconds but design very small
- ⊘ 3mm² full of diffractive structures in 5s
- ⊘ 5 x 1mm of text in 5s

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II.2 Laser

Two lasers were tested in WP1:

- High energy laser oscillator
- 10 kHz laser amplifier


Following the results of WP1 and the first design study of Amplitude, the Consortium has chosen the amplifier configuration and has decided in the development to place a special emphasis on processing speed.

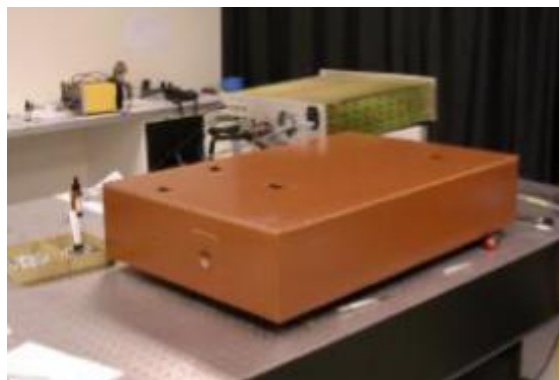
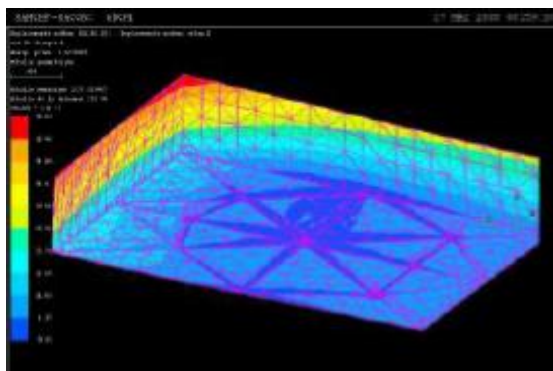
The new laser developed has the following specifications:

- ü Pulse Energy Compatible with all applications
- ü Pulse duration Non aggressive process
- ü Beam quality High resolution, small spot size

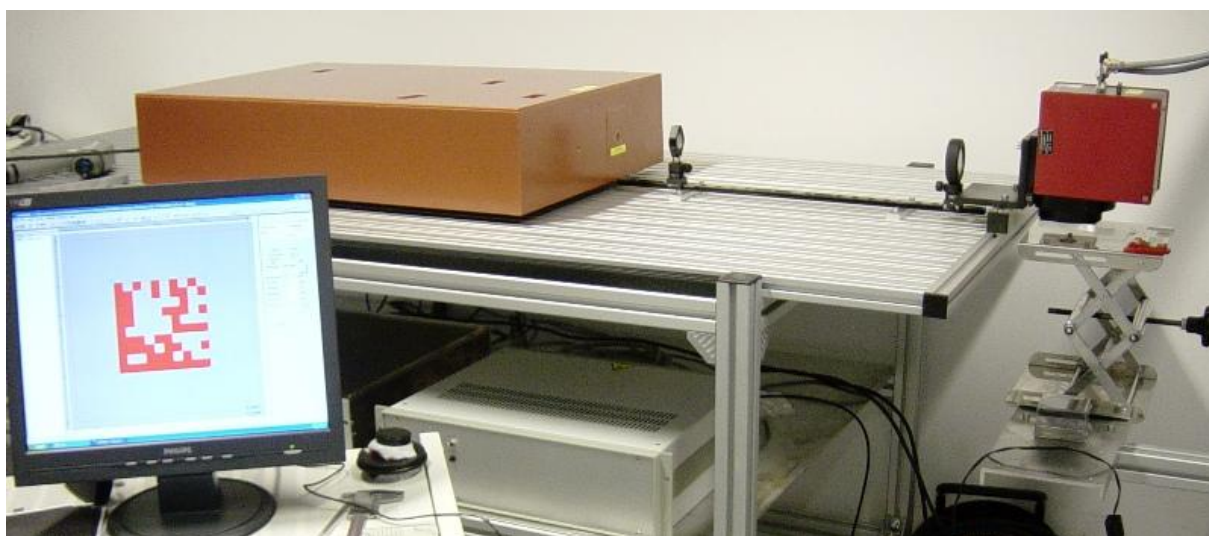
In comparison to the initial performances expected, the Consortium has decided to be more ambitious by increasing the repetition rate by 10. This should reduce speed obtained during the validation phase by a factor 5 or 10 depending of the applications.

- ü Repetition rate 100 kHz better than expected to reduce process time
- ü Industrial specifications Sealed, rugged laser source


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The new laser source has been developed and manufactured and tested during the second year. It was integrated first in a laboratory configuration and then in the prototype at the end of the project (July – October 2006)



Laboratory configuration

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II.3 Control System

II.3.1 Vision system


The vision systems have been developed for normative and anticounterfeiting applications. They have been manufactured and validated on samples of WP1 and on new samples realized during a validation phase during the WP3 in Bordeaux.

Results:

- ü Backlight with a mask aligned with camera's axis is the optimum lighting solution to read datamatrix codes made by structural change & refractive index change
- ü Marking by structural and refractive index change give the best results in terms of reading performances.
- ü Datamatrix code from 1x1 mm to 60x60 µm are readable
- ü One CCD camera mounted with one special lens can cover datamatrix size from 1x1 mm to 60x60 µm



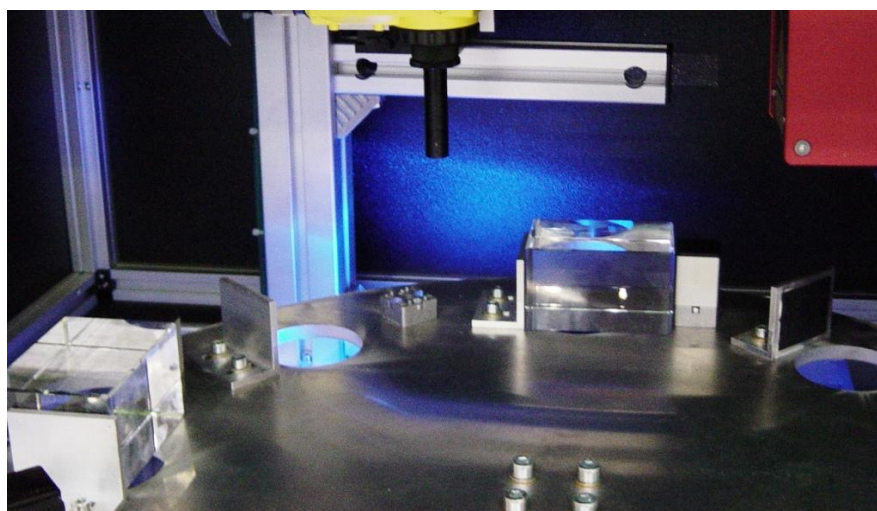
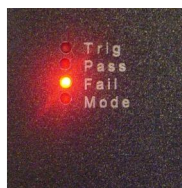
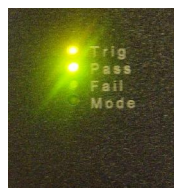
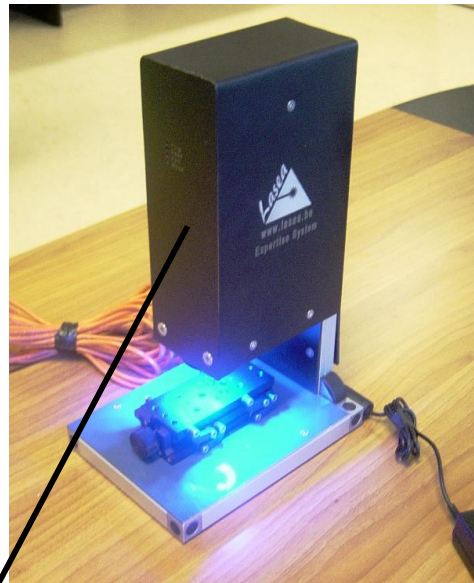
Fixed and portable systems have been developed the second year:

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PORTABLE SYSTEM

Specifications

- ü Vision system
- ü camera & software (Ethernet & USB)
- ü User friendly system
- ü easy to handle products and code finding
- ü Special lighting Rugged and high lifetime lighting for high contrast and industrial use
- ü Portative system
- ü Easy to transport (suitcase of less than 7Kg)



Fixed reading system

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II.3.2 Optical system

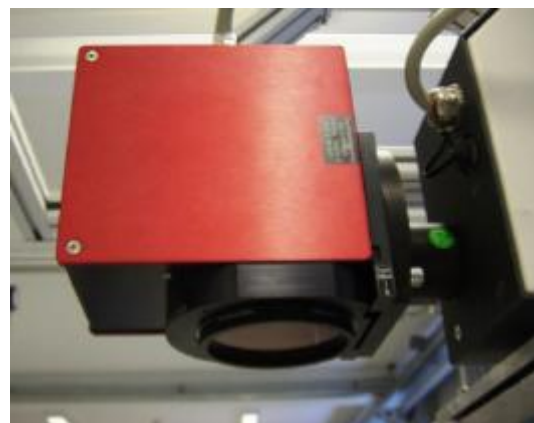
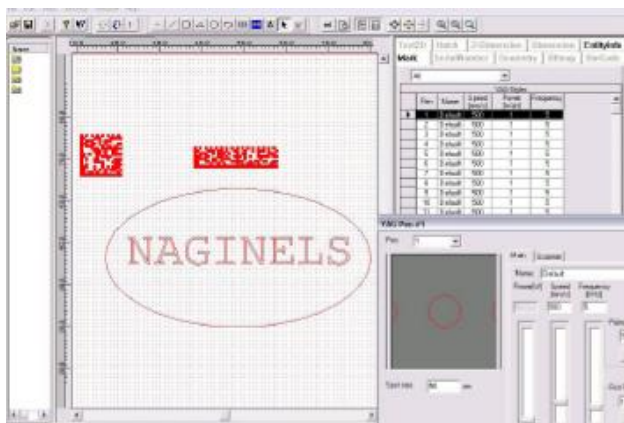
Different optical systems have been developed and tested in order to obtain the precision and field size expected. These systems have been validated thanks to YAG laser in Liège and fs laser in Bordeaux. They have been validated with the new laser during the phase 4 & phase 6. Many systems have been tested and optimised in order to get the best compromise between quality and flexibility for integration issues.




Lenses

II.3.3 Control system

Electronic card, galva head for the transport of the beam, software and communications between laser and these subsystems have been studied. Final system have been developed and manufactured. It has been validated with the new laser during the integration phase (WP4).



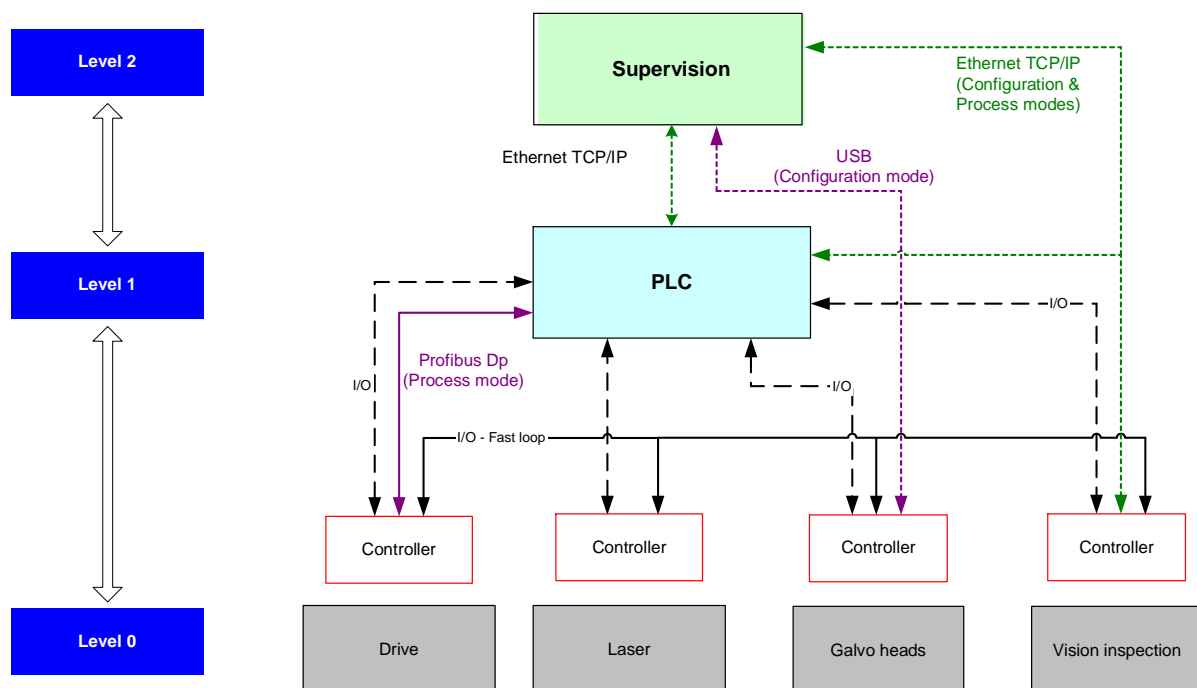
 NAGINELS Non Aggressive Glass Internal Engraving Laser System	Deliverable No 8.7	Final Activity Report – Section 1	
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II.4 Prototype


The prototype is not supposed to be an industrial unit but it must be realistic in terms of working rate, accuracy, reliability and safety concept. The prototype covers the engraving (marking) process (laser) and the marking verification (vision system). This verification gives an immediate feedback on the readability and quality of the engraved code. The prototype has the flexibility to comply with these specific requirements. It's accurate enough to engrave a code on the small vials, but also able to treat bigger bottles.

Development has been finalized during the second year and the manufacturing phase was finished in July. The prototype has been shown during international fair Glasstec 2006 in Düsseldorf.

General architecture:



Control equipment – General architecture

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Main screen of the HMI :

PROTOTYPE : CONTROL (100 - V2.0) LOGIN USER: KST

Maintenance Parameters Control Summary Alarm Reset DATE : 15/09/2006 TIME : 10:31:13

NAGINELS
Non Aggressive Glass Internal Engraving Laser System

☒ PC CONTROL

BEACON LIGHTS
☒ OBTURATOR OPEN
☐ WORKING
☐ ALARM/WARNING
☐ LASING

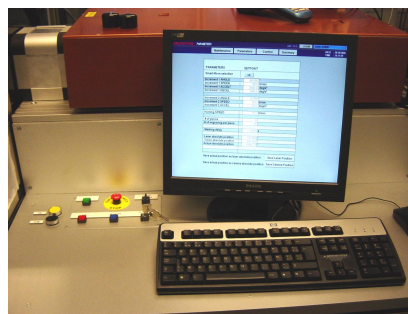
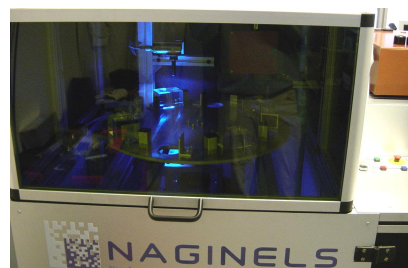
PIECE COUNTER
ENGRAVING COUNTER
ACTUAL POSITION OF THE PLATE °
ACTUAL SPEED tr/min
NUMBER OF GOOD RESULT

Ack	Date In	Time In	Description
✓	15/09/2006	10:03:57	LASER WARNING : OSCILLATOR NOT STABLE
✓	15/09/2006	10:03:57	LASER WARNING : AMPLIFICATOR TROUBLE
✓	15/09/2006	10:03:57	HOUSING INTERLOCK BYPASS


Total Alarms: 3 Filter: Off Sort: Time In, Descending

Control view

Pictures



NAGINELS Prototype

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II.5 Final validation

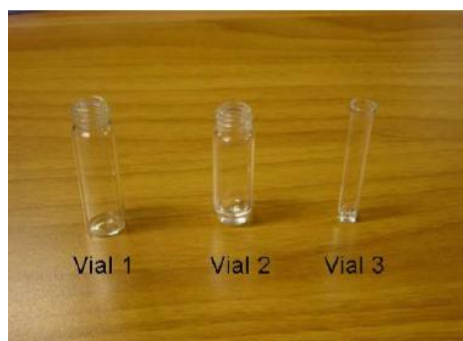
Many samples & products have been engraved and red during the validation phase/



Bottles and vials



Watches



Vials




Disks for mastering



Perfume bottles



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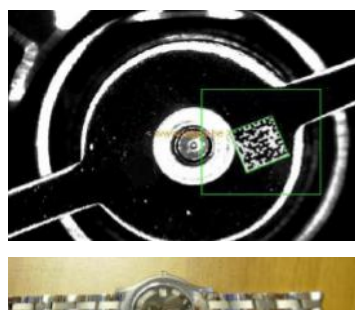
Summary of the results


Quality depends mainly of the surface of the product and the depth of the marking:

		Depth	1x1mm 20x20 cells	0.5x0.5mm 20x20 cells	0.3x0.3mm 16x16 cells	0.2x0.2mm 14x14 cells
Pharmaceutical vials		0.1mm	G	G	G	G
		0.5mm	G	G	G	G
		1mm	G	G	G	G
		2mm	G	G	G	G
Float glass		0.1mm	G	G	G	G
		0.5mm	G	G	G	G
		1mm	G	G	G	G
		2mm	G	G	G	G
Watches glass		0.1mm	G	G	G	G
		0.5mm	G	G	G	G
		1mm	G	G	G	G
		2mm	G	G	G	G
Special glass for mastering		0.1mm	G	G	G	G
		0.5mm	G	G	G	G
		1mm	G	G	G	G
		2mm	G	G	G	G

Reading Quality: G=Good, A= Average, P=Poor, -=Unreadable

Reading quality vs glass type

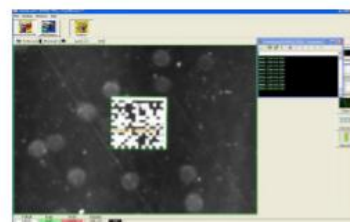



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		Depth	1x1mm 20x20 cells	0.5x0.5mm 20x20 cells	0.3x0.3mm 16x16 cells	0.2x0.2mm 14x14 cells
Perfume bottle s	Good Surface Quality	0.1mm	G	G	G	A
		0.5mm	P	A	A	A
		1mm	P	A	A	A
		2mm	P	P	P	P
	Low Surface Quality	0.1mm	P	P	P	P
		0.5mm	-	-	-	-
		1mm	-	-	-	-
		2mm	-	-	-	-
	Clear Green coating	0.1mm	A	A	A	A
		0.5mm	A	A	A	A
		1mm	A	A	A	A
		2mm	A	A	A	A
	Dark and Opaque Coatings	0.1mm	-	-	-	-
		0.5mm	-	-	-	-
		1mm	-	-	-	-
		2mm	-	-	-	-
	Coloured	0.1mm	P	P	P	P
		0.5mm	-	-	-	-
		1mm	-	-	-	-
		2mm	-	-	-	-

Reading Quality: G=Good, A= Average, P=Poor, -=Unreadable

Reading quality vs perfume bottle type



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Speed depends mainly of the size of the code (and then the capacity for readable invisible codes):

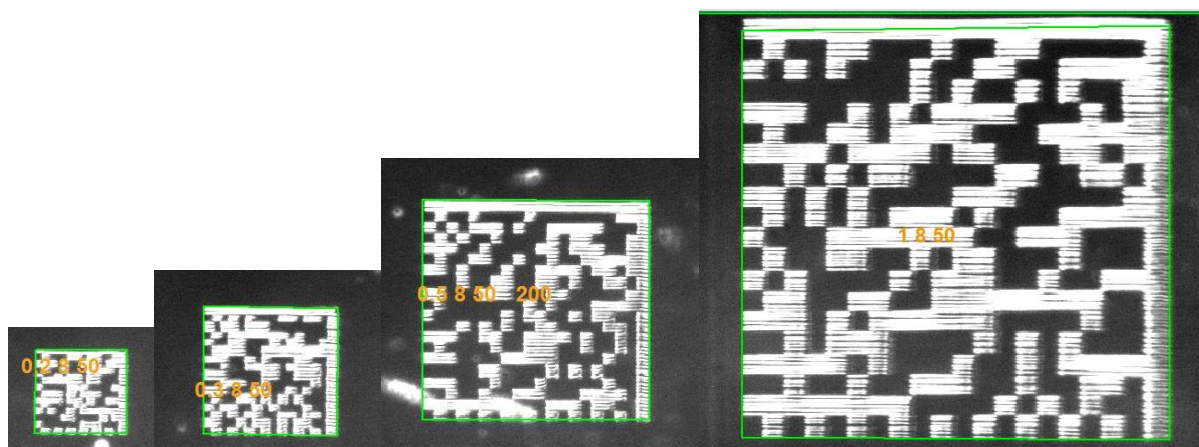
Datamatrix	Code capacity	Time
1x1mm	20x20	1.74s
1x1mm	16x16	1.68s
0.5x0.5mm	20x20	0.48s
0.5x0.5mm	16x16	0.47s
0.3x0.3mm	16x16	0.19s
0.2x0.2mm	14x14	0.1s

Text	Code capacity	Time
1x1mm	16 characters	1.03s
0.5x0.5mm	16 characters	0.29s
0.3x0.3mm	16 characters	0.13s


Code capacity vs cycle time



data matrix code and alpha numerical code



Engravings in vials (0.2x0.2mm, 0.3x0.3mm, 0.5x0.5mm, 1x1mm)

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II.6 Diffusion of Results

II.6.1 Web site

A web site has been created and registered www.naginels.com. Two main parts have been created:

1. A part for potential customer
2. A restrictive part for members of Consortium.

II.6.2 Patent


This patent was not foreseen in the initial project but the results were so good that a patent protection was discussed at the end of 2004. The decision was taken by the SBB in June in Bordeaux and confirmed during the SBB meeting in Liège in July. The patent was deposited the 28 September 2005 under the reference 01803916.2.

The title is: “*Procédé de marquage interne par laser dans les matériaux transparents et laser et dispositif utilisés pour l’application de ce procédé*”. The patent has 37 claims, 44 pages of description including the pre-existing know-how of the two RTDs companies.

A PCT version was deposited in September 2006.

II.6.3 Norms


Since June, SBB took the decision to create a new task in order to enter in the specifications of the ACCORD norm which will be active in France since the 1st January 2006 and extended in European Union the year after. The Consortium has had a lot of meetings with the people and companies involved in the new anti-counterfeiting norm and create strong links with companies involved in protective number (like Kessler codes).

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II.6.4 Publications

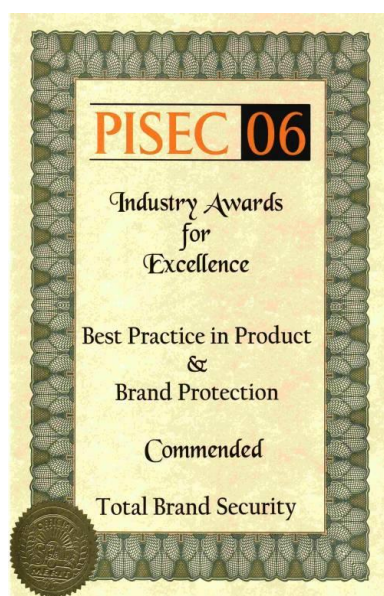
Even if the Consortium has decided not to release any scientific publications, some articles were written in general press or specialised press by the Consortium and presentations have been made:

- » 15th November 2005 Conference CRIF
- » 17th November 2005 Conference WTCM
- » November 2005 Press release in packaging magazine « Rassegna dell'imballaggio »
- » November Press release in « Pira International » (see the fortnightly electronic newsletter "Brand protection news" on Piranet.com) focusing on the glass market
- » 19/01/06 Interview (RTL-TV news 19h)
- » 20/01/06 Article in www.in-pharmatechnologist.com (news stories and data of value to decision-makers in pharmaceutical technology in Europe)
- » January 2006 / February 2006 Press paper from "Photoniques" N° 21 January-February 2006
- » Février 2006 Norme : AC Z60-100 (AFNOR) Prévention et dissuasion techniques pour la lutte anti-contrefaçon (protection des droits de propriété intellectuelle) – Spécifications d'un cadre générique décrivant les dispositions d'authentification des produits, d'organisation de la traçabilité et de contrôle dédiées à la lutte anti-contrefaçon
- » 07/03/06 Article in www.piranet.com (the leading online business resource for the printing, packaging, publishing and paper industries)
- » Mai 2006 Article in "The Packaging professional"
- » From 17/05/06 to 18/05/06 ESPACE LASER Trade Fair (France)
- » 16/06/06 Demonstration organised in Geneva by M. RUGGIERO from ALL4R. (Presentation of the Naginels codes)
- » From 26/09/06 to 29/09/06 MICRONORA 2006 International Microtechnology Trade Fair (Besançon, FRANCE) 2 booths
- » Sept/Oct 2006 Article in "Product and Image Security" "ONE TO ONE" Magazine Profile Product & Image Security focuses on the information concerning the problems of counterfeiting, ... The magazine features articles related to security materials, security holograms and applications (Product identification, authentication, traceability, brand image protection...)


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- » 09/10/06 Conference about the Seventh Framework Programme 2007-2013 (University of Liège)
 - » From the 24/10/06 to the 28/10/06 GLASSTEC International trade fair In Düsseldorf. International exhibition of machines and glass production technics
 - » 10/11/06 Conference in a Pharmaceutical industry in Milano
 - » 07/12/06 Press paper from “Les Echos” (French economic newspaper)
 - § December Press paper from “Verre” VOL.11 N°6
 - §
- (see web site www.naginel.com/news)

The first world introduction of the Naginels concept was at the **PISEC Barcelona Congress**—a world authority on everything related to brand protection (from the 2/10 to 4/10/ 2006). The result of this was winning an award for Naginels for excellence for Best Practice in Product and Brand Protection (<http://www.pisec-world.com>):



An industry specific presentation of Naginels was made at the **IQPC in London**. This was attended by all the leading pharmaceutical companies around the world and a booth was made up and presented by Total Brand Security Ltd. We presented using a booth together with other leading technology providers directed towards the pharmaceutical industry.

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II.6.5 Glasstec exhibition


Naginels exhibited on Glasstec, the World's largest Glass Trade Fair from 24th to 28th October 2006 (booth 11A40 B). This was very important as the leading glass manufacturers of the world attend this global fair and so do their major customers.



Prototype was shown for the first time. Demonstrations of the machine and the reading systems were organized. Potential customers and end-users were invited.

Glasstec received more than 55.000 visitors which more than 150 visited our booth. We got over 20 important leads all over the world for the Naginels concept which we are following up on.



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II.6.6 Conclusions

The Naginels technology is of great interest to many different market segments and therefore the strategy behind disseminating the results as efficiently as possible has been multi pronged. The main markets of interest are the following;

- ü Pharmaceutical
- ü Perfume and cosmetics
- ü Wines and spirits
- ü Watches
- ü Precious stones —diamonds etc
- ü Automotive
- ü The glass industry


Each of these industries have their own specific strategies of market penetration and each of these markets were addressed using the following;

- » Insertion into specialized press publications; <http://www.iom3.org/pp/may06/news.htm>
- » Using global news services for examples; http://presszoom.com/story_118356.html
- » Direct e-mail directly to specialized responsible
- » Applications for industry specific awards -- see below
- » Inclusion of Naginels specific search words in Internet search
- » Inclusion into the consortium member websites
- » Participation in conferences
- » Individual customer visits and presentations
- » Individual seminars to groups of customers
- » Participation in Congresses and specialized forums

The most important independent way to address the specialized press is to make use of specialized reporters that can write independent articles describing the features advantages and benefits of the Naginels technology. This was successful in the following publications (see some examples below);

- ü Brand security “Future of Laser Marking in Perfumes”
- ü Product and Image Security
- ü Brand protection news
- ü Financial Times
- ü ...

See our web site: www.naginels.com/news

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Proposal Number	512931	Proposal Acronym	NAGINELS

II.6.7 Future management of the results

Thanks to this R&D program, technology is validated and a prototype is available for new researches, optimization and demonstration to potential customers.

A new company has to be created in the following weeks for the industrial phase of this new technology and the commercialization. The partners have to work now on the reduction of price of this high level laser system and on the possibility of a quick integration of the technology in one of the end-user's plant.

TrackInside®

Your solution for tracking, tracing and authentication for the primary package.

→ European commission sponsored project dedicated to industrialising a new high tech non aggressive laser marking system.(Patent pending)

→ Trackinside® has the following characteristics:

- Visible or invisible codes
- Easily readable (grade A - AIM)
- Process time <0,5s
- Non aggressive - no cracks or physical stresses.


We Offer:

→ Full integration on your production lines.

Vision systems for reading:

- On your production line
- In the market Place

→ Software linking Input/Output data to your ERP database.



250 x 250 µm





60x60 µm !!!

