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Potomac Photonics and *Pumori-Engineering Invest*:

Our client always keeps pace with the times and does not waste money on equipment which will be hopelessly outdated tomorrow

Pumori-Engineering Invest **and** ***Potomac Photonics*** **jointly participated in the ExpoElectronics 2008. In the course of the Expo, representatives from the editorial board of the** ***Technologies in Electronics Industry*** **journal interviewed Dr. Paul Christensen, founder of** ***Potomac Photonics, and Natalia Dolmatova, project manager in charge of dissemination of Potomac Photonics technologies in Russia***

Paul CHRISTENSEN, **founder of** *Potomac Photonics*	**Natalia DOLMATOVA,** ***project manager in charge of dissemination of Potomac Photonics technologies in Russia***

About the company

Pumori-Engineering Invest, LTD (Ekaterinburg, Russia) is an engineering enterprise within the Urals Machine Building Corporation (Pumori-SIZ) specializing in supplying comprehensive sets of equipment and technologies for many branches of industry. Cooperation with Potomac Photonics, a US company, and dissemination of its systems for laser micro-processing and technologies for direct fabrication of conductors (without masks) is one of the very promising directions in the work of the company.

– Could you say a few words about the company, its history and its technologies?

P.C.: Potomac Photonics was founded in 1982. Initially, we developed only lasers. Today, however, directions of our work include development of sophisticated laser equipment and provision of services in the area of laser micro-processing. In 1999-2000 we decided to explore the possibility of using our laser technologies in microelectronics. For this purpose, we joined efforts with the US Naval Research Laboratory – which is financed by the US Government – and for three years jointly participated in MICE (Mesoscopic Integrated Conformal Electronics). The purpose of the project was to develop technologies for small-batch production of miniaturized electronic components (10-100 microns) by way of 3-D deposition (based on CAD data) of passive and active components onto practically any low-temperature substrates (<200°C) using CAD files and without using masks. Within the MICE program, Potomac Photonics developed three techniques for direct fabrication of the circuit board pattern: Contact Transfer, *Mill & Fill*, and *Ablate & Plate.*

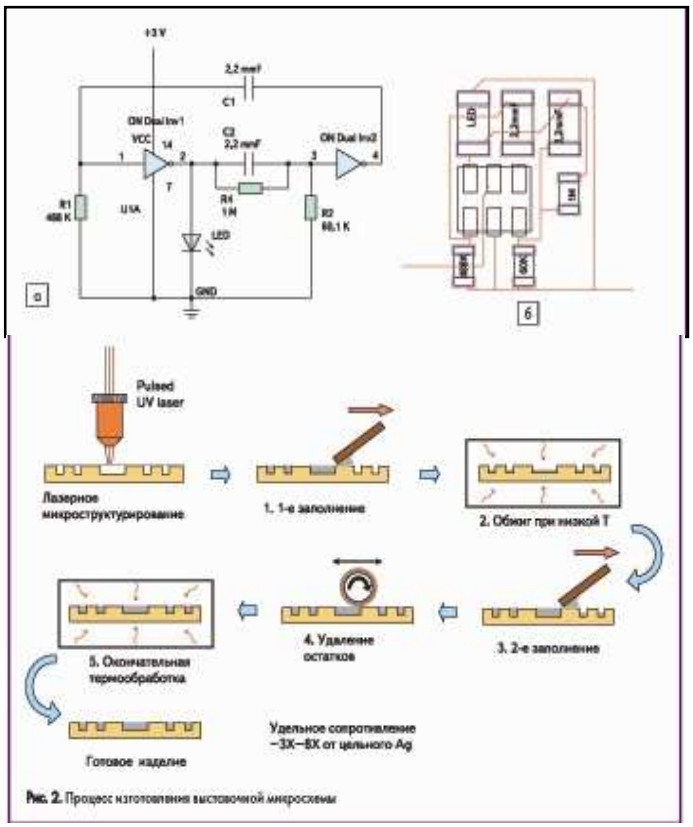

Рис. 2. Процесс изготовления выставочной микросхемы

– What motivated this effort?

P.C.: The driving force of evolution in electronics, regardless of the specific area of application – civil, military, air and space – is the necessity to reduce costs and improve functionality (this is true in case of computers, cell phones, GPS systems, satellite components…). The evolution of semiconductor microchips has shown that this combination of low cost and improved functionality may be achieved only through miniaturization. Besides, many electronic devices gain from miniaturization per se, even if it is not accompanied by lower costs or improved functionality (here I am talking about information transmitting or information processing devices, e.g., implants, satellite components, etc.). These market requirements represent a permanent driving force for miniaturization in electronics. The latest models coming from the Asian production lines and the latest

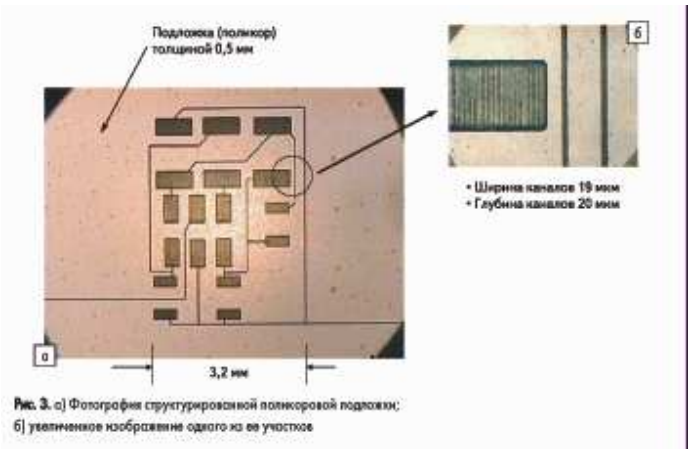

Рис. 3. а) Фотография структурированной поликоровой подложки; б) увеличенное изображение одного из ее участков

Intel microprocessors are a case in point. We can say that everything that can be miniaturized will be miniaturized sooner or later.

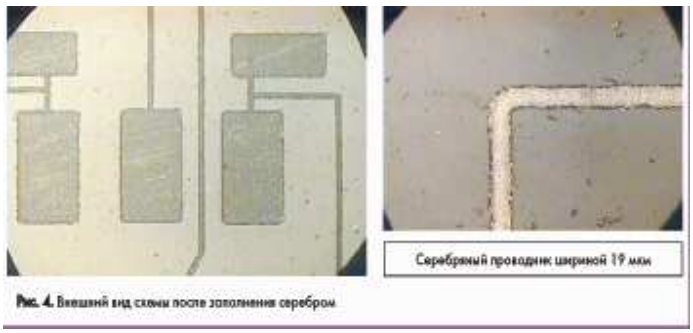

Рис. 4. Внешний вид схемы после заполнения серебром

The concept of conductors planted on a substrate has come as a response to the need for a high level of miniaturization. The ability to make microchips smaller is usually restricted by how much smaller the conductors and passive components can possibly be. Technology for planted conductors uses the energy and focusing capacity of a high-quality laser beam for creating 6 micron wide conductors with controlled depth. Reduced size of the conductors and contact bases enables the highest degree of miniaturization of the surface pattern components. Moreover, small planted conductors can be run between contact bases and underneath passive components which make it possible to reduce the number of micro transitions and layers in the substrate. Such small, simplified configurations are a perfect way of achieving miniaturization and utilizing its full potential.

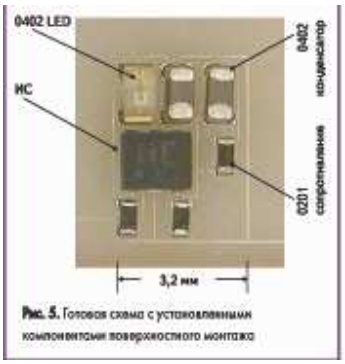

Рис. 5. Готовая схема с установленными компонентами поверхностного монтажа

Those producers of electronic devices who are already aware of the necessity to reduce costs, increase functionality and achieve a higher degree of miniaturization often prefer to address this problem in a gradual, evolutionary manner. Today their circuit boards hold 75 micron conductors, a year from now they are going to introduce several 50 micron components circuit boards, in another year – a few 30 micron components, and so on. The ultra-violet laser makes such evolutionary approaches possible, whereby developers can use components of increasingly smaller sizes. For instance, systems with solid state UV-lasers may be used to create individual 50-micron segments on the circuit boards fabricated by using the traditional photolithographic method. Further modernization of the system will enable this type of laser to form segments with a more dense pattern of 30 micron conductors on various substrates and with subsequent metallization. If 20-micron elements are needed, the system may be further modernized to draw planted conductors. The modern stage in the development of this technology makes it possible to reduce the size of components to 6 microns and even less. And all these processes are performed by the same UV-laser by modernizing the beam generation system and the peripheral equipment.

Some of the results were presented here, at the expo; in particular, boards with conductors planted on the substrate. We decided that this approach enables considerable miniaturization of electronic devices as a whole. The fact of the matter is that traditional ways of fabrication of the pattern of conductors do not allow for size

reduction below 50 microns, whereas modern electronic production requires further miniaturization of conductors and spaces between them. This is why we are seeking ways of producing increasingly thinner conductors. In the course of one of the projects that we implemented for one of our US clients we managed to produce conductors and spacing whose size did not exceed 6-8 microns.

The clue here is that the laser performs micro-milling of the substrate according to the data in the CAD file, after which the resulting structure is filled in two ways – either by injecting power-conducting paste or by silver-plating. We work with both organic and inorganic substrates; in particular, on our display board you can see samples made on policor and polyimide substrates – although we also work with other materials, such as ABF (Ajinomoto Build-up Film). For this expo, we developed a sample where you can clearly see the potential of our technology. If you take a close look at the circuit (Fig. 1), you can see that using traditional approaches it cannot be made in one layer. However, due to the fact that out technology makes it possible to draw conductors underneath the surface components and does not require micro-transitions, we managed to make the entire chip in a single layer.

Fig. 2 schematically shows how the chip was made. We used a policor substrate, on which we formed the pattern for the conductors (shown in Fig.1) by laser micro-milling. The resulting channels were then filled with a special silver paste. The filling was done in two stages with sintering between the stages. With organic substrates we use low-temperature pastes (sintering temperature normally does not exceed 200-250°C, depending on the stability of the substrate).

Fig. 3 is a photo of a structured policor substrate and a magnified photo of one of its segments. In this case, the conductors were 19 microns wide, and the entire circuit board was 3.5 mm. Fig.4 shows the same circuit board after it was filled with silver, and Fig.5 is a photo of the same circuit board when it is finished and all surface components are installed. Here we used the smallest components that can be found on the market today: 3 resistors, capacitors and the microchip which controls this circuit. This is a very simple example illustrating the main potential uses of our technology.

– So, does this mean that you have various lasers and you already know which of them may be used on which surfaces?

P.C.: For working with organic substrates, we use ultraviolet radiation, given that UV waves are absorbed by organic substances better than anything else. This radiation can be generated by excimer lasers that operate at a bandwidth of 308 or 248 nm, or by solid-state UV lasers operating at 355 nm.

Excimer lasers generate high-energy impulses of relatively non-coherent light with the frequency of impulses in the kilohertz range. Given the difficulty of focusing the resultant light and the low frequency of impulses, these lasers are normally used in combination with masks which project the image of part of the circuit onto the surface of the substrate. This is similar to a slide projector, where a laser is used instead of the bulb. The source of

energy in excimer lasers is a set of discharges produced by a mix of halogen gases which has to be replenished after a certain number of impulses.

Solid state UV lasers make low energy impulses of light that is easy to focus with a high frequency of impulses (from several dozen kilohertz to several dozen megahertz). Equipment with solid state UV lasers uses high-speed scanning to enable rapid movement of the focused beam over the surface of the substrate and fabrication of the circuit pattern. In this case, the circuit pattern is programmed and therefore no mask is needed. The energy for solid state UV lasers is provided by laser diodes. This type of lasers is very reliable.

Both excimer and solid state UV lasers are used in order to create patterns for planting conductors on substrates. A simple analysis can show that systems with excimer lasers need to have higher productivity and better control of the depth of channel for planted conductors. Despite the large volume of work already performed using excimer lasers, there are still a number of serious issues which have not been fully resolved, including replicability of results, interaction of radiation with the substrate, maintenance, inputs and generation of masks. At the same time, solid state UV lasers are continuously modernized, their capacity keeps increasing and their price keeps dropping. Furthermore, a new concept of beam delivery has been developed for high-output industrial systems. As a result, solid state UV lasers have become an excellent choice, not only for prototyping systems, but also for industrial systems and production.

– And how about certification?

P.C.: The services of our company are ISO certified, and a certificate of compliance is issued for every piece of our equipment. Regarding the technologies, here the certification probably has to be conducted in every country separately, in compliance with the local standards.

– When a technology is proposed, normally there would be some mention of the required inputs. In any case, Russia cannot work with some specific materials.

P.C.: We came to the conclusion that for high-temperature processes, where electronic equipment has to work in an aggressive environment, policor substrate is the most acceptable material. There is also another kind of material that is popular practically everywhere – it is polyimide. I think ABF has to come third – it is a build-up film produced by the Japanese company Ajinomoto.

– What is the proposed laser system like?

N.D.: The set of equipment is developed by our partners based on requirements set by a specific client, because *Potomac Photonics* is an engineering company, same as *Pumori*. We do have a similar approach to achieving our objectives: unlike companies who offer mass produced equipment, we do not tell the client “here is a laser system, here are its capabilities, and you have to adjust your needs proceeding

from this". *Potomac Photonics* develops each unit proceeding from what you need today, leaving a possibility for modernization in the future without substantial additional costs. Thus, our client always keeps pace with the times and does not waste money on equipment which will be hopelessly outdated tomorrow.

– When did you enter the Russian market and why?

P.C.: We learned from *Pumori-Engineering Invest*, which contacted us, that the Russian market needed our technology, and in the course of our contacts we came to know that several businesses were seriously interested in the systems that we develop.
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– Do you think your technology will be popular in Russia?

P.C.: It has already been recognized all over the world. We see that Russia keeps pace with the times, with the global trends. Miniaturization is a goal which all producers of electronics all over the world are trying to reach right now, and the laser is the instrument which makes it possible to reach new "special" horizons. We have developed a simple technological chain which enables a stage-by-stage transition from 50-micron conductors/spacing on FR4 to 6-micron ones using the most modern substrate materials. We also offer transition from prototypical to serial production, whereas the same type of the laser system will serve as the "heart" of each process.

N.D.: Russian businesses do have an interest in the technologies developed by our partners; we can state this with all confidence, although our cooperation with *Potomac Photonics* is still relatively young. I made several presentations at the seminars held by the *Guild of Equipment Technologists*, and the initial reaction of the audience to the samples was "this is out of a science fiction movie!" However, we are already working with some of them quite actively and we are convinced that that these groundbreaking technologies that we discussed today will help our national businesses to be competitive.

– ***And the last question: what do you think about ExpoElectronics, what are your impressions?***

P.C.: This Expo represents diversity, a variety of approaches. I think it will evolve in the future, will become increasingly prestigious and interesting. Its visitors have a good opportunity to see new equipment. For a company like ours it is also very important to establish direct contacts with potential clients, to meet people, to understand what they really wish.

The interview was conducted by
Arkadiy MEDVEDEV and Olga ZAITSEVA