PHOTRONICS IS ON THE MOVE—
MAJOR EXPANSION INTO CHINA!

PHOTRONICS eBeam Phase Masks
(continued from pg 5)

PHOTRONICS, Inc.
15 Secor Road
Brookfield, CT 06804

In his new role with Photronics, J. Gregory Hickey will utilize his 23 years of business and public accounting experience to enhance the performance of Photronics global treasury functions. His primary focus will be on organizing the Company’s treasury department to increase their efficiency.

Sean Smith has over 18 years public accounting experience. Most recently, Mr. Smith was Vice President & Controller for Photronics, where his responsibilities included all financial reporting and analysis, budgeting and forecasting, and purchasing.

Mr. Bollo, after having served as Chief Financial Officer for more than seven years, retired from the Company for personal reasons. In acknowledging Mr. Bollo’s role in Photronics’ success, Mr. Macricostas commented, “Bob leaves Photronics a much stronger Company today than when he joined us seven years ago. The Board, our employees, and our shareholders are grateful for his efforts. We wish him well in his new endeavors.”

To read the full press release on this story, visit our website at www.photronics.com.

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Reticle and Mask
SOLUTIONS

PHOTRONICS eBEAM PHASE MASKS:
Tackling the Challenges of Special Lightwave Applications

In this issue of SOLUTIONS newsletter has customarily focused on reticle technology needs of advanced semiconductor manufacturers, over the past few years we have seen an increasing need to apply R&D resources to areas outside the semiconductor industry. There are numerous technologies that use lithography in fields such as data storage, biomedical and optical networks. Several of these applications are based on the routing, manipulation or sensing of light in a media or free space and therefore can be classified as photonics applications.

These applications have specific mask requirements that often do not differ radically from those of our core semiconductor customers. However, some have slight twists that make them unique enough to require a special development effort. Often, these efforts are simply form factor differences, which themselves can be quite challenging. Sometimes the efforts can be more complex, requiring development of specialized write strategies, resist and etch processes and unique metrology.

The Form Factor Challenge

The semiconductor industry has standardized on a 6” X 6” X 0.250”(6025) fused silica substrate for most advanced semiconductor needs. The current substrate has well-defined standards that were developed under the auspices of our core group of semiconductor customers as well. Watch for more new product news in future issues of SOLUTIONS.

Summary

Photronics has indeed risen to the multiple challenges in FBG phase mask product development and now has a world-class product to offer to the optical networking and fiber sensor markets. This is just one example of many ongoing efforts to continually expand our product offering in the micro and nano pattern transfer arena. A number of exciting efforts are underway that will expand our reach into more of these markets, and may offer benefits to our core group of semiconductor customers as well.

PHOTRONICS Strengthens Management Team With Key Promotions

Company Positioned for Future Growth

Designed to strengthen the Company’s management team and position them for future growth, Photronics recently announced several senior-level promotions. Effective immediately, Dan Del Rosario has been named CEO, replacing Constantine S. Macricostas. Executive VP and COO, Paul J. Figi, has been elected President of the Company. J. Gregory Hickey, currently Treasurer, has been promoted to Vice President. Sean Smith, currently Vice President and Controller, has been promoted to Chief Financial Officer, replacing Robert Bollo.

Mr. Macricostas stated, “This well designed succession plan is a key component of the Company’s strategy to address future opportunities.” He noted that the history and chemistry of the group will serve the Company well, and help maintain its momentum toward expansion and growth.

Mr. Del Rosario has been with the Company since 1995. Prior to his promotion, he served Photronics as Senior Vice President/Asia. Under his skillful leadership, the Company has seized a competitive lead in this region.

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CyberMask: Creating a Virtual Window for Photronics Customers

Online Tools Help Streamline Business Processes and Reduce Mask Specification Errors

As part of our commitment to customer service, Photronics has introduced CyberMask™, an innovative thin-client software solution that revolutionizes and streamlines the production of photomasks. Designed to support the needs of our customers, CyberMask extends flexible customer service facilities into customer accounts, streamlining workflows, reducing manual intervention during photomask fabrication and increasing customer access to scheduling and production status information via the web.

A product of the Photronics Advanced Technology Data Center (ATDC), CyberMask is based on the SenTIO data specifications—industry-standard data streams that permit cross-enterprise exchange of technical specifications for photomask manufacturing. Using the ATDC’s sophisticated information technology infrastructure, CyberMask serves as the front-end of a management, manipulation and storage solution that is designed to deal with the explosive growth in data file size associated with customer design data required for photomask production. Current data file sizes for 130 nanometer technology devices approach 90 gigabytes. In 2005, the industry’s technology roadmaps expect these files will exceed 300 gigabytes! Photronics is working with our customers to maximize manufacturing efficiencies and greatly reduce cycle times by applying the full potential of information technology to this industry-wide problem.

Front-end processes automated through CyberMask include:

• Order entry
• Data preparation
• Directing the job to manufacturing facility

CyberMask is aimed at customers across all technology nodes. Immediate customer benefits include:

• Cycle time reduction
• Data reduction
• Optimized resource utilization
• Improved operations while processing increasingly complex mask requirements
• Establishment of a single point of entry when placing orders through Photronics

Initial results indicate that CyberMask can help reduce the order entry and job initiation process by 50% or more through its fully-automated procedures, while simultaneously reducing errors incurred during processing. By leveraging the benefits of centralized, automated processing and advanced tools such as data verification engines, Photronics’ customers receive better service with improved satisfaction and quality levels. By reducing processing workload after customer submission, Photronics is able to support customers more efficiently, all while reducing total support costs.

CyberMask is currently implemented in our Allen, Texas facility, and is being deployed throughout the Photronics manufacturing infrastructure. Major customer accounts will be trained on its use, as plant sites are fully trained.

Anticipating customer migration to high-volume 130nm node production during 2002, Photronics’ high-end manufacturing teams spent much of 2001 working with our most advanced customers to roll out the manufacturing technologies needed to support their latest requirements. The solutions resulting from this effort are reflected in our Nano Technology Line (NTL) tools.

The first suite of Nano Technology Line tools were installed in our state-of-the-art manufacturing facility in Taiwan. The NTL is anchored by two new lithography systems housed in the Taiwan Semiconductor Manufacturing Corporation (TSMC) and United Microelectronics Corporation (UMC), among the largest foundries in the world. These foundries, including Asian suppliers Taiwan Semiconductor Manufacturing Corporation, are setting new standards for advanced wafer process technology. Our Nano Technology Line tools are designed to meet their most challenging development and volume requirements. However, our NTL systems also align our advanced manufacturing and process development capabilities with the leading captive photomask facilities run by our major customers.

Global Deployment

While NTL deployment began in the Asia/Pacific market, we are equally committed to the high-end manufacturing demands of our major semiconductor customers in other major semiconductor markets. Our NTL systems are also ramping into production in Europe, beginning with our Manchester (UK) facility. In North America, our initial NTL systems are being installed in our technologically advanced facility in Austin, Texas. Since these two additional facilities are qualified, global customers will have convenient regional access to the industry’s most advanced manufacturing facilities for reticles at the 130nm node and below.

Planning for the Future

The initial rollout of the NTL toolset is designed to support volume production demands at the 130nm node which we anticipate in 2002. However, the move to the next major tech node, 90nm, is already underway. Photronics Taiwan is actively developing 90nm process technology with prototype reticles scheduled for July 2002. This technology will utilize both positive and negative chemically amplified resist (CAR). Photronics Taiwan is currently slated to offer binary, EAPSM (e-Phase®) and AAPSM (1-Phase®) reticles at the 90nm node.

Photronics is also continuously working to improve overall efficiency of our high-end manufacturing processes. A key component in this process is the migration of critical processes to our advanced reticle manufacturing toolsets. As part of this effort, Photronics is focusing on the introduction of new technology tools with increased process capability and reduced sensitivity to defects. As part of our High Volume Reticle Technology (HVRT) program, we have implemented a new technology process that will allow the migration of critical processes from the 130nm into the 90nm technology node.

Installation of our initial Nano Technology Line systems in Taiwan reflects our strong desire to sustain regional technological leadership and support what we forecast will be the largest single market for 130nm technology in 2002.

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Photronics eBeam Phase Masks

(continued from pg 7)

of the Semiconductor Equipment and Materials Institute (SEMI) standards committee, in which Photronics has taken an active role. The SEMI specifications also define governing criteria for other substrates used in mask making. Since 3X and 4X reticles for advanced semiconductor applications are our dominant core business, a substantial part of our investment in equipment and process development goes into optimizing performance of the 6025 form factor. It therefore becomes challenging to deliver the same high quality our advanced semiconductor customers enjoy on substrates that differ from the standard.

Since photronics customers producing planar waveguide and other structures are frequently accomplishing lithographic imaging in the 1X regime on six-inch wafers, the optimum substrate for high performance masks is not an option for them. These customers mostly need to work with seven-inch substrates, which are available from our suppliers, though not as readily as or with as high quality and consistency as the preferred 6025 form factor. A similar condition exists with substrates smaller than six-inch; the consistency of the coatings on these substrate sizes do not approach that of the 6025 substrate and make achieving equivalent high resolution and critical dimension uniformity more challenging.

In addition to the difficulty of using a form factor for which the supply is limited or the quality is lower than the industry benchmark, our process lines are often optimized for the substrate size and process development to accommodate substrates other than 6025. This new condition is being accentuated by the fact that mask requirements for most of these applications could be enhanced by dry etch capability. This special feature need extends to the array of inspection and metrology equipment that is at our disposal for standard size semiconductor reticles.

Photronics is addressing the form factor matter in a number of ways. Our product strategy team is busy identifying applications where demand is significant enough to invest in the required fixtures and metrology capabilities to meet these needs and thereby get out in front of our customers. We have recently committed to prototype manufacturing of five-inch alternating-aperture phase shift masks for customers wishing to extend the lithographic capability of their 9X1-line and DUV steppers. We are also beginning to investigate on-demand absorber deposition and resist application as a means of handling the high resolution and optical property obstacles presented by many of our customers.

The FBG Phase Mask Example

Photronics recently announced its entrance into the Fiber Bragg Grating (FBG) phase mask business after a nine-month joint effort with customer development partners. FBG phase masks are very similar to alternating aperture phase shift masks used by advanced semiconductor manufacturers that they require high resolution line widths of around 520nm at the mask plane—roughly the equivalent of 180nm node 4X reticles. They also require etched trenches

with precise, highly uniform depths and sidewall angle control. The similarity ends with these criteria, however, as FBG phase masks have several other attributes that are rarely considered in a semiconductor mask fab.

The first significant challenge in manufacturing FBG phase masks is pitch control over the entire length of the grating. These masks require pitches controlled to a few picometers with no subpicometer stochastic errors, which cause unwanted out-of-band reflection in the optical fiber. The write tool had to be carefully considered and unique write strategy had to be developed to solve this problem. Many of the masks also require gradually changing pitches from as low as 30-50 picometer/centimeter to as high as 50 or more picometer/centimeter. Our "SnugFit" patent-pending write strategy, developed to accomplish this feat, has been met with high praise from customers in evaluation and is now being used in manufacturing.

The second significant challenge in FBG phase mask manufacturing is a two-pronged one that is squarely centered in the form factor arena. Most customers have established processes that require substrate thicknesses of less than the benchmark 0.250. This raises the topic of producing uniform high-resolution features equivalent to the most advanced semiconductor application on non-optimum substrates. Our team responded to this by optimizing the resist, dissolve and develop parameters to best meet these needs. The second and more perplexing part of this form factor concern centers around the fact that most customers do not use mask sizes that conform to the aforementioned SEMI standards. This means that after writing and processing a mask with 180° uniform phase shifted edges and picometer pitch precision in a Class 1 clean room, the mask has to be cut into a smaller form factor without damage to the mask image.

Our development team overcame this problem by creating a special coating process to protect the mask during the cutting operation, followed by a cleaning process to restore the masks to the pristine condition they were in when they left the clean room. From customer feedback, Photronics is confident that its FBG phase masks are the cleanest available in the industry.

Another challenge has been the development of metrology tools that measure the critical mask parameters that matter to this new customer group. Three initially requested by our semiconductor customers. In an FBG phase mask, diffraction efficiency is a critical parameter. None of the standard metrology equipment in a semiconductor

Asian manufacturing network now supports a number of new key technologies: Right: Jim Funada, Managing Director and Yozo Hosoya, Director of Sales—a chance to introduce themselves to the Japanese market. Customers...
**BACUS Review**

**BACUS 2001**

Photronics at the forefront of mask technology

The largest annual technology symposium dedicated specifically to photomask technology issues, better known as BACUS, was held in Monterey, California from October 2-5, 2001. BACUS— the 21st SPIE Photomask Technology Conference—was chaired by Guang Diao of Intel Corp. and Brian Greson of Greson Consulting Inc. Highly prioritized by Photronics, our aim was to present the work we have done in the previous year to further mask technology, and to present a strong technical capability image to our current and potential customers. To that end, we have three of our own employees serving on the Program Committee that oversees the paper selection and conference content.

Photronics submitted a total of 15 papers to BACUS, making Photronics one of the top five companies by the number of presentations submitted. Photronics had excellent representation this year. Of the 130 total papers submitted to the conference from all over the world, 15 were from Photronics. This total was among the highest of any company represented. A breakdown of the authors and their work is as follows:

- S.H. Jung (PKL) — "Investigation of dry etching of modified fused silica for 157nm alternating aperture phase-shift masks"
- Peter Blythin and Pat Martin (Allen) and Monica Nnai (NCO) with Canon — "150nm dense/isolated contact hole study with Canon (NCO) with Canon"
- Bryan Kasprowicz and Darren Taylor (Allen) — "Tip shape effects in scanning probe metrology"
- Feng Qian and David Chan (Austin) with ULVAC — "Gray bar masking: fabrication and imaging for 193nm"
- Peter Rhyins and Pat Martin (Allen) and Monica Suis — "Defects analysis of mask blanks"
- Matt Lassiter (Allen) — "Investigation of dry etching of modified fused silica for 157nm alternating aperture phase-shift masks"
- Bryan Kasprowicz and Darren Taylor (Allen) — "Comparison of 2D measurement methodologies and their viability in a manufacturing environment"
- Rich Morse (D2W) — "Highly versatile tapeout automation system"
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The conference was attended more lightly than usual due to travel restrictions resulting from both the economic downturn and events of September 11, 2001. However, there was good regional representation in the audience and no papers were pulled for lack of available presenters. Conversely, this year was the first time simultaneous sessions were run due to the number of categories and issues mask makers face. This is a sign that the conference is growing in response to the overall needs of the mask industry.

The program started off with a keynote address by Howard Charney, VP of Marketing for Cisco Systems. His delivery was essentially an audio-visual demonstration of various internet conveniences, educating the audience about the impact of every web interaction. Charney’s presentation was filled with pictures and videos illustrating how the Internet is changing endlessly. The audience was breathless in amazement from the multimedia presentations, which are clearly leading the way in today’s technology. As the keynote speaker, Charney was able to present a significant amount of information to the audience.

The conference is sponsored by SPIE and featured both presentation sessions and poster sessions. Poster sessions are informal and provide a unique opportunity for attendees to interact directly with presenters, ask questions, and exchange ideas. Photronics was a major supporter of BACUS and had a significant presence at the conference, with a large booth and a dedicated representative team.

**Expansion into China**

This most recent quality initiative is part of our total customer service program, aimed at helping Photronics maintain its global leadership position in reticle technology.

Photronics will provide critical data integration and optical extension services required by Chinese semiconductor design and foundry companies. China requires additional design integration and all other equipment to support Photronics’ SRS™ manufacturing processes.

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Photronics has retained DNV (Det Norske Veritas) and BSI (British Standards Institute), two leading international certification organizations, as the auditors and registrars for our certification program and achievement.

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