Zsolt Nényei: An Early Pioneer in Rapid Thermal Processing

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Rapid Thermal Processing (RTP) is a technology that has been around since the late 1960's. Remarkably this is almost as long as the first integrated circuit (IC) processing. Yet, whereas the ICs have been a great and unsurpassed success story in semiconductor technology from its start early on, RTP is considered as an established worldwide spread technology only since the mid-1990's.

In the mid-1980's quite a few start-up companies had introduced their RTP equipment for processing 100 mm and 150 mm diameter silicon wafers. Only a few companies were successful in implementing an annealing process to form the titanium silicide contacts for the ~0.7 μm Si technology nodes and beyond. AG Associates with their tungsten-halogen lamp-array system and Peak Systems with their single xenon arc discharge lamp were successful market leaders, but hardly realized that it was mainly the relatively wide process window of the non-critical titanium silicide process that allowed the early commercial introduction of RTP.

In spite of its promise of reduced thermal budget processing, RTP kept facing skepticism, mostly because the equipment manufacturers and the end user community did not recognize and understand its basic challenges in *temperature uniformity* and *repeatability* [1]. Too long RTP reactors were viewed as chemical mini-furnaces governed by chemistry rather than optical reactors, governed by thermophysics in terms of the effective emissivity of layered, non-patterned and patterned wafers and of reactor cavity design. It is only since the break-through modeling work by Hill *et al*. [2], the introduction of the ripple-technique in pyrometry [3,4] and the introduction of truly production-worthy equipment that the technology became rapidly accepted.

It is now over two decades ago that I first visited AST Elektronik, a young company in Blaubeuren (Germany), on a mission to assess the best RTP equipment for Philips' future semiconductor plants worldwide. AST Elektronik was a young company with many skilled technical people in a highly innovative atmosphere. It had just appeared on the market with a tungsten-halogen lamp-array system using a novel concept of OH-containing quartz reactor envelop to exclude stray radiation from lamps into the pyrometer [5]. Meeting two persons here particularly impressed us: *Heinrich Walk*, focusing on the hardware and *Zsolt Nényei*, focusing on low temperature budget processing. This couple discussed the wealth of new concepts that AST Elektronik then had on its roadmap to overcome the barriers for worldwide acceptance of RTP as the mainstay thermal processing technology.

The company had a very open mind for innovation, which was led by these two inspiring persons. Their enthusiasm made it possible to co-prototype with Philips a processor for Rapid Thermal Magnetic Annealing of thin magnetic films with superior performance for use in magnetic heads [6-8].

Many RTP equipment suppliers did not survive during the consolidation in the 1990's. Also AST Elektronik as a company underwent several acquisitions and mergers, but survived in the Mattson consortium as one of the few strong players in today's RTP market. Interestingly, both early concepts of tungsten-halogen lamps and the arc discharge lamp survived in Mattson's latest 'flash-RTP' tools. Here a smart combination of lamp powering and optical cavity reactor chamber design enables milliseconds high-temperature pulses to manufacture advanced CMOS with ultra-shallow junctions, etc.

It is essential for successful companies to rely on backbone personalities like Zsolt. Now that he will retire as of May 2008, the semiconductor manufacturing community will loose a pioneer of the first hours of advanced commercial low thermal budget processing. His contributions, especially his break-through work on pattern-induced non-uniformities, both experimental and theoretical, are highly recognized in the RTP community. One of the Awards he won for his collective work was at the International RTP'99 Conference 'in recognition of his contribution to application of RTP'.

Above all, we will loose a modest, passionate scientist who combined his broad and thorough scientific knowledge with a drive to develop concepts to fully established and commercialized technology and to stimulate colleagues and partners, young and old. This special issue contains contributions by specialists from all over the world showing the state of perfection and maturity of RTP as a commodity technology in modern semiconductor manufacturing. I gratefully join the editors and volunteer authors in dedicating this document to Zsolt Nényei, one of the early pioneers in Rapid Thermal Processing.

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References

[1] F. Roozeboom (ed.): *Advances in Rapid Thermal and Integrated Processing*, NATO ASI Series E, Vol. 318, Kluwer Academic Publishers, Dordrecht, The Netherlands (1996).

[2] C. Hill, S. Jones and D. Boys: *Rapid Thermal Annealing – Theory and practice*, in *Reduced Thermal Processing for ULSI*, edited by R.A. Levy, NATO ASI Series B, Vol. 207, Plenum Press, New York (1989), pp. 143-180.

[3] C.W. Schietinger, B.E. Adams and C.B. Yarling: *Ripple technique: a novel non-contact wafer emissivity and temperature method for RTP*, Mater. Res. Soc. Symp. Proc. Vol. 224 (1991), pp. 23-31.

[4] C.W. Schietinger and B.E. Adams: *Non-contact techniques for measuring temperature or radiation-heated objects*, US Patent 5,154,512, Oct. 13 (1992).

[5] F. Roozeboom: *Manufacturing equipment issues in Rapid Thermal Processing,* in *Rapid Thermal Processing, Science and Technology* edited by R.B. Fair, Academic Press, New York (1993), pp. 349-423.

[6] F. Roozeboom, J.J.M. Ruigrok, W. Klaassens, H. Kegel, M. Falter and H. Walk: *Rapid thermal magnetic annealing: a novel technique in thin-film recording head production?*, Mater. Res. Soc. Symp. Proc. Vol. 429 (1996), pp. 203-210.

[7] F. Roozeboom, S. Abedrabbo, N.M. Ravindra, H. Walk, and M. Falter: *Rapid thermal magnetic annealing as an emerging technology in field annealing of thin magnetic films for recording heads*, Mat. Sci. Semicond. Proc. Vol. 1 (1998), pp. 303-315.

[8] F. Roozeboom, P.J.H. Bloemen, W. Klaassens, E.G.J. van de Riet and J.J.T.M. Donkers: *Soft-magnetic fluxguide materials*, Philips J. Res. Vol. 51 (1998), pp. 59-91.