### 6.2 ELYMAT and CELLO Research

### 6.2.1 ELYMAT

We have encountered the ELYMAT (=short for ELectrolYtical MetAl Tracing) <u>before</u>; it was a product of my Siemens years.

In Kiel, J. Carstensen vastly enlarged on the theory, enabling new modes, and W. Lippik adopted the machinery to square-shaped multi-crystalline Si wafers as used for solar cells. We also cooperated with Bernd Eichinger and his company GeMeTec that marketed a commercial version of the Elymat. The Elymat was top in characterizing starting materials, i.e. "raw" silicon and with its help wafers of all kinds became more or less perfect. Very satisfying but with the catch that the Elymet eventually outlived its usefulness.

Mapping parameters of finished solar cells became more pressing and that's where CELLO comes in.

### **Publications**

Same list as <u>before</u>, just shown again for completeness.

If thee number of citations is give (in *red italics*), the paper can be found by Google Scholar; so I mostly won't make a link to the papers here-

- Not counting minor proceedings etc,. we have the following publications (including the ones from the Kiel time):
- 58 <u>LEHMANN, V., FÖLL, H.</u>: Minority carrier diffusion length mapping in silicon wafers using a Si-electrolyte-contact. J. Electrochem. Soc., 135 (1988) 2831 E (155 citation That is tie first publication intriducing the method.
- 63 FÖLL. H., LEHMANN, V., ZOTH, G., GELSDORF, F., GÖTTINGER, B.: In-line monitoring of heavy metal contaminations and interface states by an imaging technique. Proc. of the Satellite Symposium to ESSDERC '89 Berlin. (Analytical Technique for Semiconductor Material and Process Characterization) (eds.: B.O. Kolbesen, D.V.Mc Caughan, W. Wandervorst) Electrochem. Soc. Proc. Vol. 90-11 (1990) 44 (invited paper)
- Following are the publications written in Kiel:
- FÖLL, H.: Life time mapping with the ELYMAT technique. Proc. Symp. "Advanced Science and Technology of Si Materials", (Jap. Soc. Promotion of Science) Kona (Hawaii) 1991, p. 347 (invited paper) 3 citations)
   FÖLL, H., LEHMANN, V., LIPPIK, W.: Characterization of single and polycrystalline silicon by extension of the ELYMAT technique. Proc. of the Satellite Symp. to ESSDERC '93 Grenoble, "Crystalline Defects and
- 74 Contamination: Their Impact and Control in Device Manufacturing", (ECS Proc. Vol. 93-15, 1993), p. 252
- 73 CARSTENSEN, J., LIPPIK, W., FÖLL, H.: Mapping of defect related bulk and surface properties with the ELYMAT technique. In Semiconductor Silicon/1994 (eds, H.R. Huff, W. Bergholz, K. Sumino),(ECS Proc. Vol. 94-10), San Francisco 1994, p. 1105 (8 citations)
  First time the name Jürgen Carstensen appears. He was a theoretical physicist, just finished with his Ph.D thesis and he joined my group to stay. He was the second in command of my group over since and without him I would

and he joined my group to stay. He was the second in command of my group ever since and without him I would have been lost.76 CARSTENSEN, J., LIPPIK, W., FÖLL, H.: Mapping of defect related silicon properties with the ELYMAT technique

- 76 CARSTENSEN, J., LIPPIK, W., FOLL, H.: Mapping of defect related silicon properties with the ELYMAT technique in three dimensions. Proc. of "Semiconductor Processing and Characterization with Laser-Applications in Photovoltaics", Stuttgart 1994, Mat. Science Res. Forum Vols. 173-174, p.159 5 citations)
- 78 CARSTENSEN, J., LIPPIK, W., LIEBERT, S., KÖSTER, S., FÖLL, H.: New developments of the ELYMAT technique. Proc. of the Satellite Symp. to ESSDERC '95 Den Haag, "Analytical Techniques for Semiconductor Materials and Process Characterisation II", Electrochem.Soc. Proc. Vol. 95-30 (1995) 83-92 The first ELYMAT publication with *color pictures* and not found by Google Scholar! That's why I provide a link to to the paper here.
- **79** CARSTENSEN, J., LIPPIK, W., LIEBERT, S., KÖSTER, S., FÖLL, H.: ELYMAT technique on multicrystalline silicon for solar cell application.. Proc. of the "13th European Photovoltaic Conference and Exhibition", Nice, Okt. 1995, p. 1344-1347 (2 citations)

Not a lot of publications, and all quite minor and not much cited. Not very successful work, in other words? Well – no! In this case we did what the Technical Faculty was supposed to do: engineering work. We were part of large projects for getting solar cell technology going, and we did many measurements for our partners from R&D and companies. The focus was not on publishing.

Maybe a quick remark is indicated:

# The world's energy problem will be overcome by employing good and cheap solar cells.

## Solar cell science and technology was developed almost exclusively in Germany

Believe it or don't. I'm for one are feeling good about having been a part, however small, of this all-important enterprise.

#### Pictures

There are almost no good (color) pictures of ELYMAT measurements left besides the ones <u>already shown</u> Here is the rest:



Once you have cleaned up your Si production – be it wafers for microelectronics or multi-crystalline square-shaped sliced for solar cells – you don't need life time mapping any more. The usefulness of the ELYMAT declined at the end of the millennium. As far as solar cell R&D was convened, you now would have liked mapping of solar cell parameteris like series resistance or surface recombination velocity. That's why we invented "<u>CELLO</u>".