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The contribution of Hans von Wartenberg to the development of the Czochralski method

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Abstract

The contribution of Hans von Wartenberg to the development of the Czochralski Method for pulling single crystals is often overlooked. He was its earliest adopter, having introduced the use of seed crystals, and his detailed description of the method was the basis for its subsequent dissemination.

1 Introduction

In his Letter to the Editor of the Journal of Crystal Growth [1], Tomaszewski rebutted the earlier assertions made by Scheel who questioned Czochralski's founding role in the development of the eponymous method for pulling single crystals from the melt [2]. To illustrate how quickly the utility of Czochralski's invention [3] for growing single crystals (called by Czochralski the "capillary method", "Capillarmethode") was recognized, Tomaszewski briefly mentions the work of its earliest adopter, Hans von Wartenberg, before listing the authors of further modifications of the method. We would like to elaborate on von Wartenberg's often overlooked contribution to the development of the process that is so crucial in the manufacture of present-day solid-state electronics [4], following our earlier communication [5].

2 Hans von Wartenberg

Hans von Wartenberg (1880–1960, Fig.1) was born in Kellinghusen (Schleswig-Holstein). He studied chemistry at the Berlin University where, after just six semesters, in May 1902, he obtained a PhD based on the dissertation "A contribution to the field of mercuric oxyhalides". Afterwards, he pursued his interest in physical chemistry by joining the team led by Walter Nernst, head of the then-new Institute of Physical Chemistry at the University of Göttingen, one of the pioneers of physical chemistry, and Nobel Prize laureate of 1920. In 1905, Nernst was invited by Max Planck to head the Department of Physical Chemistry at the Humboldt University of Berlin and took von Wartenberg with him. In 1913, von Wartenberg, by then an associated professor at the Berlin University, moved to Gda´nsk to teach physical and later inorganic chemistry at the Gdańsk University of Technology – then Königliche Technische Hochschule zu Danzig. There, he obtained tenure and became the head of the Department of Inorganic Chemistry (1918–1933). In 1933, he returned to the University of G¨ottingen where he directed the Institute of Inorganic Chemistry until he was forced to resign in 1937 due to his wife's Jewish extraction. He continued his research with modest means un-

til his reinstatement in 1945 and pursued further experimental work until he passed away in 1960 [6–10].

Hans von Wartenberg published approx. 150 papers, mostly on thermochemistry. His achievements include, among other things, the demonstration of the formation of ozone through thermal dissociation of oxygen, the obtaining of several fluorides, e.g. PbF4, BiF4, CeF4, CrF3, CrF4, and CrF5, measurement of the melting points of platinum, palladium, tungsten, and thorium, and also the calculation of the boiling points of silver and chromium based on their vapour pressures [9].

His work on thermochemistry required access to electrical infrastructure, which, towards the end of the First World War, was not available at the Gdańsk University of Technology. Because of that, his former PhD supervisor, Nernst, invited von Wartenberg to finish his research at the well-equipped laboratory in Berlin. Incidentally, Berlin was where Czochralski, an employee of AEG, invented his method for measuring the crystallization velocity of metals the previous year.

3 Von Wartenberg and Czochralski

During this time von Wartenberg was working, among other things, on the elastic after-effects in metals such as zinc, for which he needed single crystals. In his paper on the crystallization rate of metals Czochralski, a competent metallurgist, correctly surmised that the product of his method is indeed a single crystal. Von Wartenberg likely learned of Czochralski's work during his stay in Berlin. He recognized that it contained what he was looking for. However, since the method for pulling single crystals was not the focus of Czochralski's work but rather its fortunate by-product, it was not described in sufficient detail to facilitate its replication. Von Wartenberg was able to obtain the missing information from Czochralski in a "friendly, written supplement to his published procedure", after which he was able to pull a single crystal of zinc "without any difficulties". Importantly, he then described the procedure of pulling the crystal in detail, including the insights from correspondence with Czochralski and his own improvement: using oriented seed crystals instead of a capillary [1,11]. Also noteworthy is the fact that in his paper, published in 1918, von Wartenberg states that he was following Czochralski's method ("Verfahren von Czochralski"), which makes him not only the method's first adopter but also its godfather, although, according to Uecker, this name became widely used only in the 1950s [12].

Von Wartenberg's detailed description of Czochralski's method was later used by Gomperz in a paper which cites von Wartenberg's work only sparingly [13]. It is this paper of Gomperz that was being referenced in subsequent publications, partly because of his modification of the process which allowed to control the diameter of the crystal fibre, and, perhaps, partly because it contained the term "single crystal" in its title, and thus facilitated indexing. From this point, von Wartenberg's contribution to the method's development was largely forgotten. He is not mentioned in Buckley's influential book "Crystal Growth" [14] which popularized the association of Czochralski's name with the method for crystal pulling [1].

Figure 1: Hans von Wartenberg, from the archive of Wiesław Wojnowski.

4 Conclusion

In our opinion, Hans von Wartenberg has played a crucial role in the development of Czochralski's method. He recognized that Czochralski's work contains the key to obtaining single crystals and was the first to use it for that purpose, improving it by introducing the use of seed crystals. Following communication with Czochralski, he described the method for crystal pulling with sufficient detail to enable its replication, and that description was the basis of all the subsequent implementations and modifications of the method. Furthermore, he was

the first to call the method after its inventor ("Verfahren von Czochralski"). Yet, this contribution is often overlooked even among von Wartenberg's other numerous and momentous works.

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