アモノサーマル法による GaN 結晶育成炉の総合熱解析

Simulation of the global thermal field in a setup for ammonothermal growth of GaN

名大未来材シス研 [1], 日本学術振興会 [2], 東北大多元研 [3], 三菱ケミカル [4], 日本製鋼所 [5]

Saskia Carola Schimmel [1,2], 冨田 大輔 [1], 斉藤 真 [3,4], 包 全喜 [3,5], 石黒 徹 [3],

本田 善央 [1], 秩父 重英 [1,3], 天野 浩 [1]

IMaSS-Nagoya Univ.[1], Int. Research Fellow of JSPS[2], IMRAM-Tohoku Univ. [3],

Mitsubishi Chemical Corp. [4], Japan Steel Works [5]

E-mail: sas.schimmel@imass.nagoya-u.ac.jp

°S. Schimmel[1,2], D. Tomida[1], M. Saito[3,4], Q. Bao[3,5], T. Ishiguro[3],

Y. Honda[1], S. F. Chichibu[1,3], H. Amano[1]

High-power and high-frequency devices are expected to benefit strongly from the availability of bulk GaN substrates grown by the ammonothermal method [1,2]. This is due to the excellent structural quality (such as low dislocation densities in the range of 10^3 to 10^4 cm^{-2} and high radius of curvature exceeding 400 m [3]) and the scalability of the method. Using the acidic variant of the technique, high growth rates of several hundreds of micrometers per day have been achieved at relatively low pressures around 100 MPa [2,3] and using silver as a comparatively inexpensive liner material [4]. In spite of these achievements, scale-up remains a time-consuming trial-and-error-based task due to the lack of knowledge on internal temperature distribution and flow field. In particular, numerical models of known accuracy are lacking.

In this study, we examine the global thermal field inside an ammonothermal growth setup (see Fig. 1) by a conjugated simulation of conductive, convective, and radiative heat transfer in order to evaluate how thermal boundary conditions should be defined in a detailed simulation of the autoclave and its interior. The results show that the temperature distribution inside the autoclave walls is not represented well by heater-long fixed temperatures at the autoclave wall, although this is a common practice in literature [5]. More specifically, thermal losses through an uninsulated autoclave head should not be neglected. Prospective alternative methods for defining the thermal boundary conditions will also be discussed.

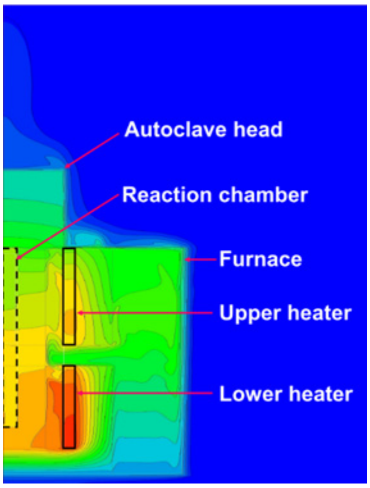

Fig. 1 Global thermal field

Acknowledgements: This work was funded by JSPS (Postdoctoral Fellowships for Research in Japan (Standard)) and partly supported by MEXT GaN R&D Project Program Grant Number JPJ005357.

[1] Dwiliński et al., Acta Phys. Pol. A **90**, 763 (1996). [2] Bao et al., Cryst. Growth Design **13**, 4158 (2013). [3] Mikawa et al., SPIE, **1128002**, 1 (2020). [4] Tomida et al., Appl. Phys. Express **13**, 055505 (2020). [5] Masuda et al., Jpn. J. Appl. Phys., **52**, 08JA05 (2013).