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Tokuyama's Prospective New Business

-- First in the World to Achieve Stable Growth of a ϕ 300-mm Ultra-Large CaF_2 Single Crystal by the CZ Method --

Tokuyama Corporation

Tokuyama Corporation (President: Shigeaki Nakahara; "Tokuyama") has become the first in the world to successfully grow an ultra-large (ϕ 300 mm) CaF_2 single crystal by the CZ (Czochralski) method, and has begun sample work. This technology has been developed for the ArF-liquid immersion stepper, which is gaining widespread attention, and is expected to accelerate the commercialization of this new type of stepper.

1. Background

Since 2000, Tokuyama has been working jointly with Professor T. Fukuda, Institute of Multidisciplinary Research for Advanced Materials of Tohoku University (Sendai, Miyagi), to grow large CaF_2 single crystals by the CZ method. We have developed single crystals of calcium fluoride as the lens material for next-generation steppers, successfully growing a 200-mm-class single crystal the year before last and (100) single crystal last year.

2. Trends in stepper technology and the meaning of the success in growing a ϕ 300-mm single crystal

Intel's announcement of last spring suggested that ArF-liquid immersion technology using an ArF excimer laser as the light source will play a central role in next-generation lithography steppers. As a result, the development of an F_2 excimer laser stepper, which was originally considered the best choice, may be skipped or simply shrunk. This will greatly change the requirements that must be met by the CaF_2 single crystal.

The F_2 laser stepper requires two lenses, one each of (111) and (100) orientations, to cancel the birefringence effect. The ArF-liquid immersion stepper, on the other hand,

requires a lens with a large diameter (at least 250 mm) (111) to meet the need for a higher numeric aperture (NA). Eventually, a lens at least 300 mm in diameter will be necessary*. There is no established system that can stably provide quality material due to some problems with lens durability and manufacturing lead time.

To meet the new needs of next-generation lithography, Tokuyama has investigated the growth of ultra-large CaF_2 single crystals over 300 mm in diameter that will be an essential element of the ArF-liquid stepper. This investigation has been conducted in the research center, Sendai, in parallel with conventional research, and has resulted in the successful development of a process that may enable stable crystal growth. This will have a great impact on the optics design and on development of the ArF-liquid immersion stepper.

This success will ensure the development of a manufacturing system that can produce lens material for ArF-liquid immersion steppers and help us prepare for the F_2-liquid immersion steppers that may be developed in the future.

3. Development and the commercialization schedule

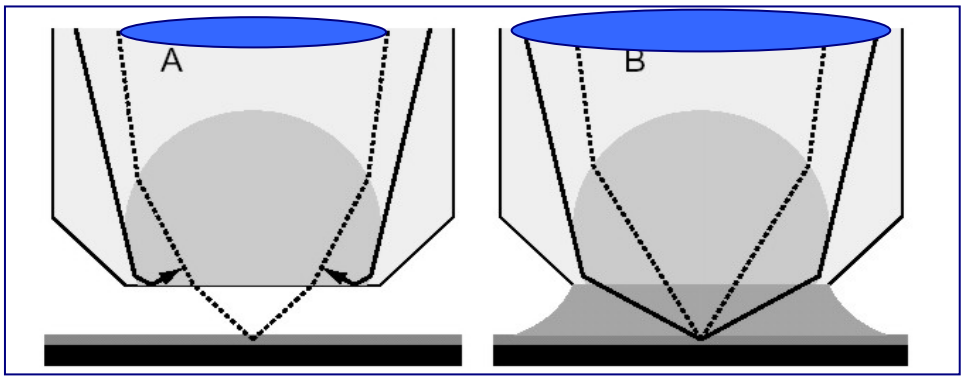
As a pioneer in the market of large fluoride single crystals grown by the CZ method, Tokuyama has manufactured fluoride-dedicated large-single-crystal growing equipment that can grow world-class crystals, and has focused on the technologies necessary to grow larger crystals and on mass production. We constructed another pilot plant (also serving as manufacturing equipment) in the research building at the Tokuyama Higashi Plant (Shunan, Yamaguchi) in spring 2003, in addition to the Sendai Plant, to establish a two-site research system. By conducting a full-scale investigation on quality improvement and mass production, we have provided stepper makers with finished products--lens blanks--as samples to be distributed to their customers since fall of last year.

While continuing sample shipments for users to try, we will start pre-marketing in the first half of FY2004 and commercialization in 2005 when the products fulfill the quality and price requirements. Under our plan, the production capacity will be 500 wafers/year

next year and then 1000 wafers/year in three years. Capital investment will reach 3 billion yen in total, as phase-in investment, and sales will total as much as 5 million yen in 2007, when the ArF-liquid immersion stepper is expected to be in wide use.

Note* Why are the immersion technology and a large lens required?

Immersion is a technology in which a liquid instead of air is filled in the gap between the wafer and the lens top to increase the overall refractivity for exposure. With a larger lens, the immersion technology provides higher resolution when a conventional light source is used. Although the original resolution of the 193-nm ArF excimer laser is 90 nm, immersion technology using pure water as the immersion liquid can increase the resolution to the level (45 nm or less) of an F_2 excimer laser using the same ArF light source.



A: dry B: immersion

Attachment: One photo of a ϕ300-mm ultra-large CaF_2 single crystal