

Crystal Illuminations

A Publication of Sawyer Research Products, Inc. September 2002



In this issue:

Introduction.....
p.1

Optical Material
Development.....
p.2,3

In-situ Observation of
Crystal Growth in
Hydrothermal
Conditions.....
p.3,4

Thin LT Wafers for
Miniaturizing Saw
Devices.....
.p.3

INTRODUCING NEW PRODUCTS

Janet Radwanski

Dear Readers,

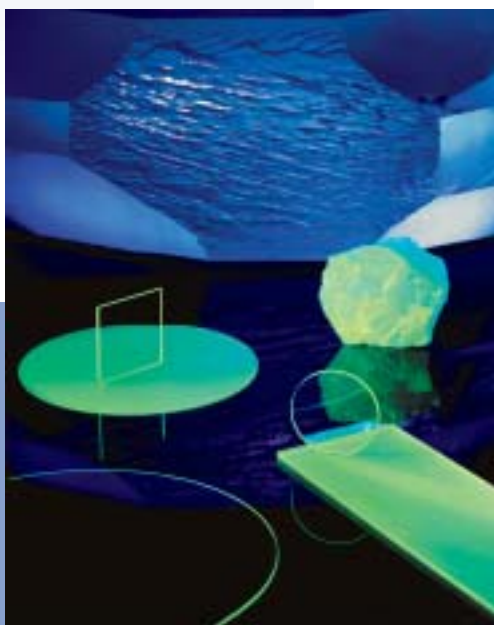
In this edition Sawyer is pleased to discuss two new products which highlight advances in both crystal growth and wafer fabrication technologies, respectively. One article concerns an optical quartz bar designed specifically to produce large diameter waveplates more cost-effectively than possible from cultured quartz crystal previously available in the market. The transmission properties and inclusion densities represent significant material quality improvements as a result of advancements in quartz growth technology. Samples are available for validating the product concept from both a dimensional and a material quality perspective.

Our previous newsletter was devoted entirely to lithium tantalate, a new product offering for Sawyer. In this edition we discuss further product development efforts that address the trend toward further miniaturizing SAW devices by reducing package height. 100-mm diameter LT wafers with a thickness of 0.25

mm are now commercially available from Sawyer for SAW applications.

The final article describes Sawyer's research efforts to observe quartz growth as it happens in real time. A caustic solution at high temperature and pressure makes in situ observations a challenge. Modeling the actual dynamics of the crystal growth process becomes difficult to achieve in the absence of such observations. We are pleased to discuss our preliminary results with this frontier technology.

There are three additional announcements we would like to make. The Sawyer web site is now running, www.sawyerresearch.com. New additions to our low dislocation quartz product line appear there in an on-line data sheet. Our Eastlake facility (quartz growth) has recently achieved ISO 9001:2000 certification. Our Conroe facility (wafer fabrication) received its certification last year. Last but not least, please visit us at our exhibit booth at the 2002 IEEE Ultrasonics Symposium in Munich, October 8th – 11th.



Optical Material Development

Ben Stein

In the fast paced optoelectronic market, the decreasing costs of consumer electronic products combined with more demanding applications are driving the optical device manufacturers to continually improve their product and fabrication process. The Sawyer Research Products Product Development team has answered this challenge by developing a new quartz crystal specifically for the optical wave plate market segment.

Quarter wave plates or retardation plates represent the vast majority of optical devices manufactured from crystal quartz. Generally speaking, wave plates are fabricated from an X or Y-cut piece of crystal quartz. Over the years, these wave plates have gotten thinner and smaller in size in response to the trend of utilizing shorter wavelengths within the visible range. New, high-powered lasers are being utilized in increasingly smaller areas or spot sizes to meet the performance requirements of more demanding consumer electronics. Due to the slow growth rate of crystal quartz in the Z direction, wave plate fabricators have

(Continued on Page 2)

(Optical Material Development Continued from p1.)

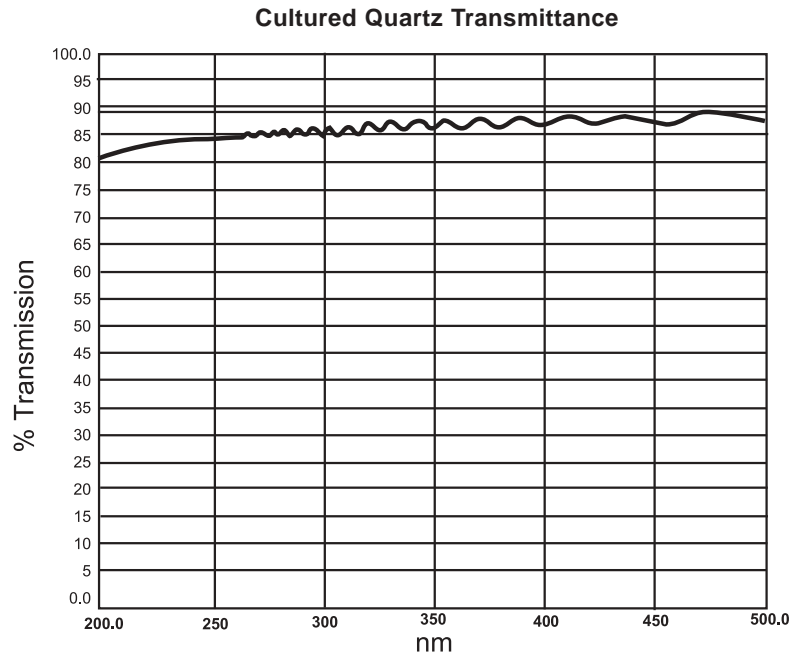
been limited to dicing final components from 1 or 2-inch diameter seed-free wafers to get full utilization of the wafer area. This limitation on the diameter of the wafer has resulted in diminished yields of finished devices from quartz wafers.

Sawyer has answered the challenge with development of the Wave Plate Bar. Sawyer's new Wave Plate Bar features:

- Near Zero Inclusions
- Near Zero Dislocations Across the Optical Surface
- Lowest Level of Impurities
- Largest, Seed-Free Usable Area
- Short Lead-Times
- Competitive Pricing

Near zero inclusions in the wave plate bar not only improves the final device transmittance or performance, it helps optical device fabricators attain higher yields on very thick parts. Zero dislocations across the optical surface reduces the internal strain within the crystal device, which results in a much-improved transmittance. Further, by utilizing pure-Z material for raw material, Wave Plate Bar material is extremely pure which also results in a much-improved transmittance. The improved transmittance of this material is evident even in the Near UV as illustrated in the chart to the right.

* The data was taken from a 30 cm thick pc of material



Sawyer's first generation wave plate bars provide optical fabricators with a large (100 mm dia) usable area to either fabricate a very large diameter quartz wave plate or a very large diameter wave plate wafer that can then be diced into small parts. Wave Plate Bar material offers customers a highly engineered product at some of the best competitive pricing and the shortest lead-times of Sawyer's product offering.

The net result is a better quality device and substantial yield improvements. The yield improvements with Sawyer Research Products' new 100 mm "seed-free" wave plate wafer are substantial as illustrated in the chart below.

DEVICE DIMENSION	DEVICES PER WAFER			YIELD IMPROVEMENTS		
	1" DIA	2"DIA	100 mm DIA	1"- 2"	1"-100 mm	2"- 100 mm
1.2 x 1.2 mm	91	385	1577	323%	309%	1633%
2 x 2 mm	43	201	813	367%	304%	1791%
3 x 3 mm	21	102	441	386%	332%	2000%
4 x 4 mm	13	64	277	392%	333%	2031%
5 x 5 mm	9	45	189	400%	320%	2000%

** The data was calculated by positioning the center of the middle device in the center of the wafer with a kerf loss of 1 mm for the blade during the dicing process.

As you can see, by utilizing Sawyer Research Products' 100 mm wave plate wafer in your optical fabrication process, your company will be able to produce up to 20X more devices per wafer.

With Wave Plate Bar material, Sawyer has created the best combination of quality, technology, price and delivery.

In-situ Observation of Quartz Crystal Growth in Hydrothermal Conditions

- from a technical paper to be published by Vladimir Klipov, Sergey Andreev & Gary Johnson

Introduction

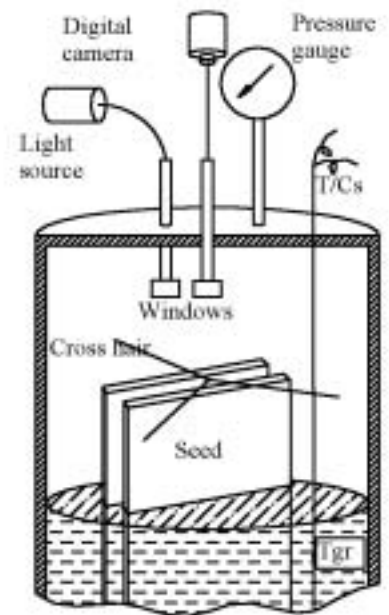
It is an old dream of researchers and engineers to observe and control the hydrothermal crystal growth process in large high-pressure industrial autoclaves. Thousands of tons of quartz crystals for electronic and optical applications are being grown worldwide annually in the dark just with temperature and pressure control in hermetically closed autoclaves. Crystal growth rate prediction and duration of these growth runs are very complicated issues for precise calculations. The error in such calculations for hundreds day-long runs is very costly to the crystal growth industry. Furthermore, direct observation of crystal growth, the hydrodynamics of convection flows, and the chemical and physical properties of the solution can give researchers and engineers an excellent tool for process control and crystal quality improvement.

Researchers have made several attempts to obtain this capability for *in-situ* observation of various solutions and crystals grown in hydrothermal conditions. The aim of the present work was to develop a direct observation technique for hydrothermal growth of quartz crystals at 340°C and under nearly 100 MPa pressure, which has never been reported.

Experimental

A specially designed optical system with two vertically positioned windows allowed direct observation of solution, seed etching, and crystal growth in the temperature range of 25-350°C under 86 MPa pressure. Experiment setup is shown on the right (Fig. 1).

A 4-liter volume steel autoclave with inner diameter of 76-mm and length of about 760 mm was used. The top of an autoclave was bored to accept feedthroughs for the experimental apparatus. Modified Dolan-Jenner Fiber-Light® with light guide as a light source was employed for crystal illuminating through one window. Kodak MDS 100 digital camera connected with computer and Schott Fiber Optics quartz fiber optic conduit were used for image taking through another window. Vein quartz placed into the bottom half of autoclave (dissolution chamber) was used as a nutrient. Four Z-cut quartz seeds (39 x 175 mm²) were wired on a two tier seed rack (not shown) and placed into the upper half of the autoclave (growth chamber). The autoclave was filled to 79% with sodium carbonate



(Continued on Page 4)

Thin Lt Wafers for Miniaturizing Saw Devices

Mark Polster

In every area of electronic components, three driving forces are continually present - "smaller, better and cheaper". This is especially true for wireless phone handsets where increasingly complex functionality must coexist with a desire for smaller and lighter handsets under the cost pressures associated with today's consumer electronics. SAW devices for frequency control and selection in wireless handsets represent some of the larger discrete components. This miniaturization trend has been well underway for cross-sectional area, or "footprint" on the circuit board, for quite some time.

As handset size continues to shrink, the package height of these components becomes a size reduction target. The trend toward integration of SAW devices into multi-function modules and the "package within a package" concept further sharpens the need to reduce package height. In turn, substrate thickness plays an increasingly important role. Current standard wafer thicknesses of 0.5mm and 0.35mm become an unacceptably high fraction of total package thickness as package heights are reduced to below 0.8mm. Using a combination of our state-of-the-art wafer fabrication equipment and our extensive process know-how and experience, Sawyer has developed the technology to produce 3 inch and 100mm diameter lithium tantalate (LT) wafers at 0.25mm thick to address the need for reduced package height.

As the diameter-thickness ratio increases, it becomes more difficult to maintain the high degree of wafer flatness required by the photolithographic processing technology used by SAW device manufacturers. The following table shows that Sawyer has achieved wafer attributes for 100mm diameter, 0.25mm thick LT wafers that are comparable to or better than the typical specifications for even thicker wafers.

	Typical Specifications 100mm dia. x 0.35mm thick	SRP Thin Wafer 100mm dia. X 0.25mm thick
Bow	< 20 μm	< 10 μm
Local Thickness Variation		
Maximum value, 5x5mm site	1.5 μm	1.0 μm
Percent of sites < 1.0 μm	95%	100%
Total Thickness Variation (TTV)	< 6 μm	< 4 μm

As with any change in SAW wafer attributes, the ability to produce the substrate wafer is only the first step in demonstrating the feasibility of the approach in producing SAW devices. The next steps will necessarily include process validation by SAW device producers as they determine the impact of thinner wafers on their processes. Nonetheless, this important first step is another demonstration of Sawyer's commitment to assure that wafer attributes are never the barrier to advancing the state of SAW device technology.

SAWYER
RESEARCH PRODUCTS
35400 Lakeland Blvd.
Eastlake, Ohio 44095
(440) 951-8770

Crystal Illuminations

A Publication of Sawyer Research Products, Inc.

(In Situ Observation of Crystal.... Continued from p3.)

aqueous solution. In order to focus the optical system, a Y-shaped cross hair formed from 0.5mm steel wire was connected to the seed rack just above the top ends of the upper seeds.

Two J-type thermocouples (T/C) inside a thermocouple well were inserted for temperature measurements inside the growth (Tgr) and dissolution (Tdis) chambers divided by a flow restrictor (not shown). Two sets of heaters connected to two Yokogawa UP 350 controllers were used in order to provide independently controlled temperatures in the dissolution and growth chambers of the autoclave.

Conclusions

For the first time, crystal growth of quartz in sodium carbonate solution could be observed *in-situ* under hydrothermal conditions. The specially designed optical system with two

vertically positioned windows allowed viewing the crystal growth at 340°C under 86 MPa pressure in a 4 liter volume steel autoclave. Crystal size control accuracy was ± 0.5 mm during 21 days of growth because of the ability to obtain clear images of the crystals. The crystal image color and the solution transparency changes were observed in an unsaturated solution during the autoclave warm up.

No visible effects were observed in the solution near the transition point between three (gas-liquid-solid) and two (liquid-solid) phases. Supersaturated solution was transparent for visual light and its index of refraction was close to that of water. Observation of movement of small particles inside the autoclave allowed estimation of the solution velocity in the range of a few cm/sec. The solution velocity was a function of the temperature difference between dissolution and growth zones.