SPTS
An orbotech Company

APPLICATION
BRIEF

Plasma Etch End-point Control

Introduction

End-point detection (EPD) is essential for many wafer etch applications to ensure processes are carefully controlled and consistent, to ensure reliable results are achieved wafer-after-wafer, and optimize device yields.

There are many methods used to end-point wafer processes and this application brief aims to describe the techniques available for SPTS's range of etch modules. The techniques either monitor the wafer thickness, analyze changes in the chemical/optical properties of the plasma above the wafer, or monitor the system datalogs.

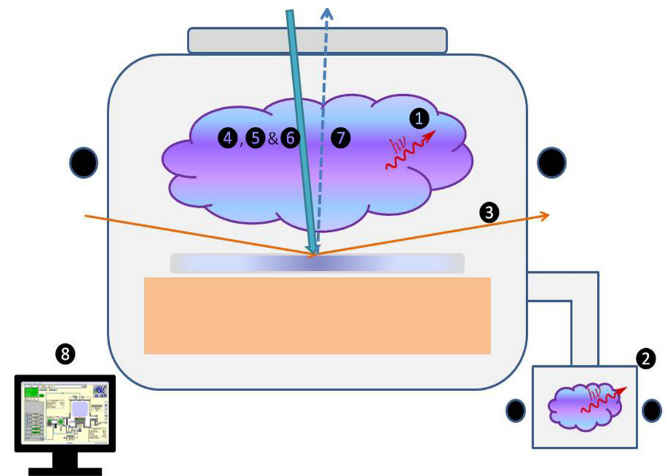

Fig. 1 Illustration showing various SPTS EPD options

	End-point Technique	Applications	Etch Modules				Comments
			ICP	Synapse	DSi & DSi-v	Rapier	
❶	**OES (Ocean, Spectraview, Filter Diode)**	Most etches to a stop layer, multi layer stacks (e.g. VCSELs), inter-wafer cleans for DRIE	✓	✓	✓	✓	
❷	**Claritas™**	DRIE etches to a stop layer or buried cavity.Inter-wafer cleans for DRIE			✓	✓	Requires OES in combination <0.05% open area capability
❸	**ReVia®**	Via Reveal				✓	
❹	**NIR**	Si thinning			✓	✓	For final Si thickness ≤45µm
❺	**White Light Reflectometry**	Tapered Si vias. Multi-layer stacks (e.g. VCSEL)	✓	✓	✓	✓	Common hardware
❻	**White Light Interferometry**	Shallow, blind etches (e.g. Si or glass)	✓	✓			
❼	**Laser Interferometry**	Compound epi etch processes	✓	✓			
❽	**Parameter**	Etch where end point is accompanied by a change in datalogged parameters	✓	✓	✓	✓	

❶ Optical Emission Spectroscopy

Optical emission spectroscopy (OES) is a technique used to analyze the light spectra emitted by a plasma during an etch process. The main advantage of OES is that it is a whole wafer technique, requiring no alignment of individual wafers, and tends to be lower cost than interferometry options. However, this method requires a stop layer, or differing layers. When the exposed area is small or the different layers are similar in composition then the change in the emission intensity is also small and can be difficult to detect.

❷ Claritas™

Claritas™, a patent protected technology (Patent US 9159599 B2) from SPTS, extends the use of existing OES options available on SPTS etch modules and enhances the detection of reactants and/or by-products. It allows end-pointing for applications even with low exposed areas (down to 0.05%) or "high pressure" processes that operate in the 100mTorr range. Claritas™ can be used for most Si etches to a stop layer as used for MEMS and TSVs (vertical via-last).

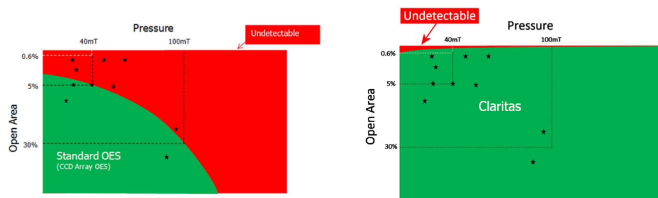

Fig. 2 Graphs illustrating enhanced capability of Claritas™ for low exposed area and/or high pressure processes

❸ ReVia®

ReVia® is a unique (Patent US 8709268 B2) end-point technique for in-situ monitoring the "via reveal" etch process. It detects the emergence of the vias during the backside etching of thinned wafers, in "via-middle" 3D-TSV packaging applications. It is capable of successful end-pointing even at remarkably low (<0.01%) via densities, and can save time and minimize yield loss in volume manufacturing.

❹ Near Infra Red (NIR)

The NIR technique uses the transparent nature of silicon to infra-red to monitor the change in wafer thickness during a silicon thinning process. With reflections off buried layers, or the opposite face of a silicon wafer, this approach can be used to end-point the thinning etch at a target thickness within 45μm of the reference surface.

❺ White Light Reflectometry

Reflectometry (and interferometry) relies on an external light source which is directed onto the wafer. The reflected light is detected and analyzed. If there is a stop layer with a different reflectivity then there will be a clear end-point signal produced. Reflectometry can be used for tapered TSV via-last etches.

❻ White Light Interferometry

Incident light will transmit through the wafer i.e. no window in the mask is required and be reflected from the interfaces between the layers, and the bottom of the etch feature, as well as from the top surface.

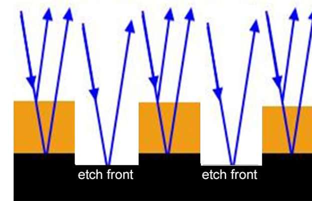

Fig. 3 Principle of Reflectance Interferometry

These reflected beams will interfere with each other, either constructively or destructively, creating a sinusoidal intensity signal with periodic oscillations called "fringes". The number of fringes will change with the changing depth of the etch front and mask thickness as it etches away (while the mask-wafer interface remains fixed), thus enabling real-time depth control and a measure of mask selectivity.

❼ Laser Interferometry

A window is required in the mask at the wafer centre to take the LASER spot which is 15-20μm diameter. The window is 300-1200μm wide for the standard set-up but when optional pattern recognition is taken this reduces to 100-400μm. The smaller window sizes correlate with the better wafer placement accuracy of the automated c2L and fxP handlers, compared to the manual LPX. Two LASER wavelengths are available - 670nm is typically used for VCSEL stacks on GaAs wafers and 980nm is typically used for InP.

❽ Parameter

System datalogs monitor many parameters of the etch process & process module including pressure, platen temperatures, RF matching, Vpp etc. In some cases, these parameters will react in the event of some change on the wafer, e.g. etch front reaching a cavity, allowing helium backpressure flow to escape or changing stress on wafer. The datalog can be used to monitor for these changes as the etch progresses triggering end-point as required.

SPTS Technologies, an Orbotech company, designs, manufactures, sells, and supports etch, PVD, CVD and MVD® wafer processing solutions for the MEMS, advanced packaging, LED, high speed RF on GaAs, and power management device markets. For more information about SPTS Technologies, email enquiries@spts.com or visit www.orbotech.com/spts

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Cautionary Statement Regarding Forward-Looking Statements

Except for historical information, the matters discussed in this press release are forward-looking statements within the meaning of the U.S. Private Securities Litigation Reform Act of 1995. These statements relate to, among other things, future prospects, developments and business strategies and involve certain risks and uncertainties. The words "anticipate," "believe," "could," "will," "plan," "expect" and "would" and similar terms and phrases, including references to assumptions, have been used in this press release to identify forward-looking statements. These forward-looking statements are made based on management's expectations and beliefs concerning future events affecting Orbotech and are subject to uncertainties and factors relating to Orbotech's operations and business environment, the previously announced acquisition of Orbotech by KLA, the manner in which the parties plan to effect the transaction, including the share repurchase program, the ability to raise additional capital necessary to complete the repurchase program within the time frame expected, the expected benefits, synergies and costs of the transaction, management plans relating to the transaction, including with respect to the Company's ownership interest in Frontline, the expected timing of the completion of the transaction, the parties' ability to complete the transaction considering the various closing conditions, including conditions related to regulatory and Orbotech shareholder approvals, the plans, strategies and objectives of management for future operations, product development, product extensions, product integration, complementary product offerings and growth opportunities in certain business areas, the potential future financial impact of the transaction, and any assumptions underlying any of the foregoing. Actual results may differ materially from those referred to in the forward-looking statements due to a number of important factors, including but not limited to the possibility that expected benefits of the transaction may not materialize as expected, that the transaction may not be timely completed, if at all, that KLA-Tencor may not be able to successfully integrate the solutions and employees of the two companies or ensure the continued performance or growth of Orbotech's products or solutions, the risk that the Company may not achieve its revenue expectations within and for 2018 (including, without limitation, due to shifting move-in dates); cyclicality in the industries in which the Company operates, the Company's supply chain management and production capacity, order cancelation (often without penalty), timing and occurrence of product acceptance (the Company defines 'bookings' and 'backlog' as purchase arrangements with customers that are based on mutually agreed terms, which, in some cases for bookings and backlog, may still be subject to completion of written documentation and may be changed or cancelled by the customer, often without penalty), fluctuations in product mix within and among divisions, worldwide economic conditions generally, especially in the industries in which the Company operates, the timing and strength of product and service offerings by the Company and its competitors, changes in business or pricing strategies, changes in the prevailing political and regulatory framework in which the relevant parties operate, including as a result of the United Kingdom's prospective withdrawal from the European Union (known as

"Brexit") and political uncertainty in the United States, or in economic or technological trends or conditions, including currency fluctuations, inflation and consumer confidence, on a global, regional or national basis, the level of consumer demand for sophisticated devices such as smart mobile devices, automotive electronics, flexible applications and devices, augmented reality/virtual reality and wearable devices, high-performance computing, liquid crystal display and organic light emitting diode screens and other sophisticated devices, the Company's global operations and its ability to comply with varying legal, regulatory, exchange, tax and customs regimes, the timing and outcome of tax audits, including the best judgment tax assessment issued by the Israel Tax Authority with respect to the audit of tax years 2012-2014 in Israel and the related criminal investigation, the Company's ability to achieve strategic initiatives, including related to its acquisition strategy, the Company's debt and corporate financing activities; the timing, final outcome and impact of the criminal matter and ongoing investigation in Korea, including any impact on existing or future business opportunities in Korea and elsewhere, any civil actions related to the Korean matter brought by third parties, including the Company's customers, which may result in monetary judgments or settlements, expenses associated with the Korean matter, and ongoing or increased hostilities in Israel and the surrounding areas.

The foregoing information should be read in connection with the Company's Annual Report on Form 20-F for the year ended December 31, 2017, and subsequent SEC filings. The Company is subject to the foregoing and other risks detailed in those reports. The Company assumes no obligation to update the information in this press release to reflect new information, future events or otherwise, except as required by law.