

SPUTTER DEPOSITION OF DIELECTRIC FILMS FOR HIGH TEMPERATURE SENSOR APPLICATIONS

H. BARTZSCH, P. FRACH, D. GLÖSS, S. BARTH
FRAUNHOFER INSTITUTE FOR ELECTRON BEAM AND PLASMA TECHNOLOGY FEP

INTRODUCTION

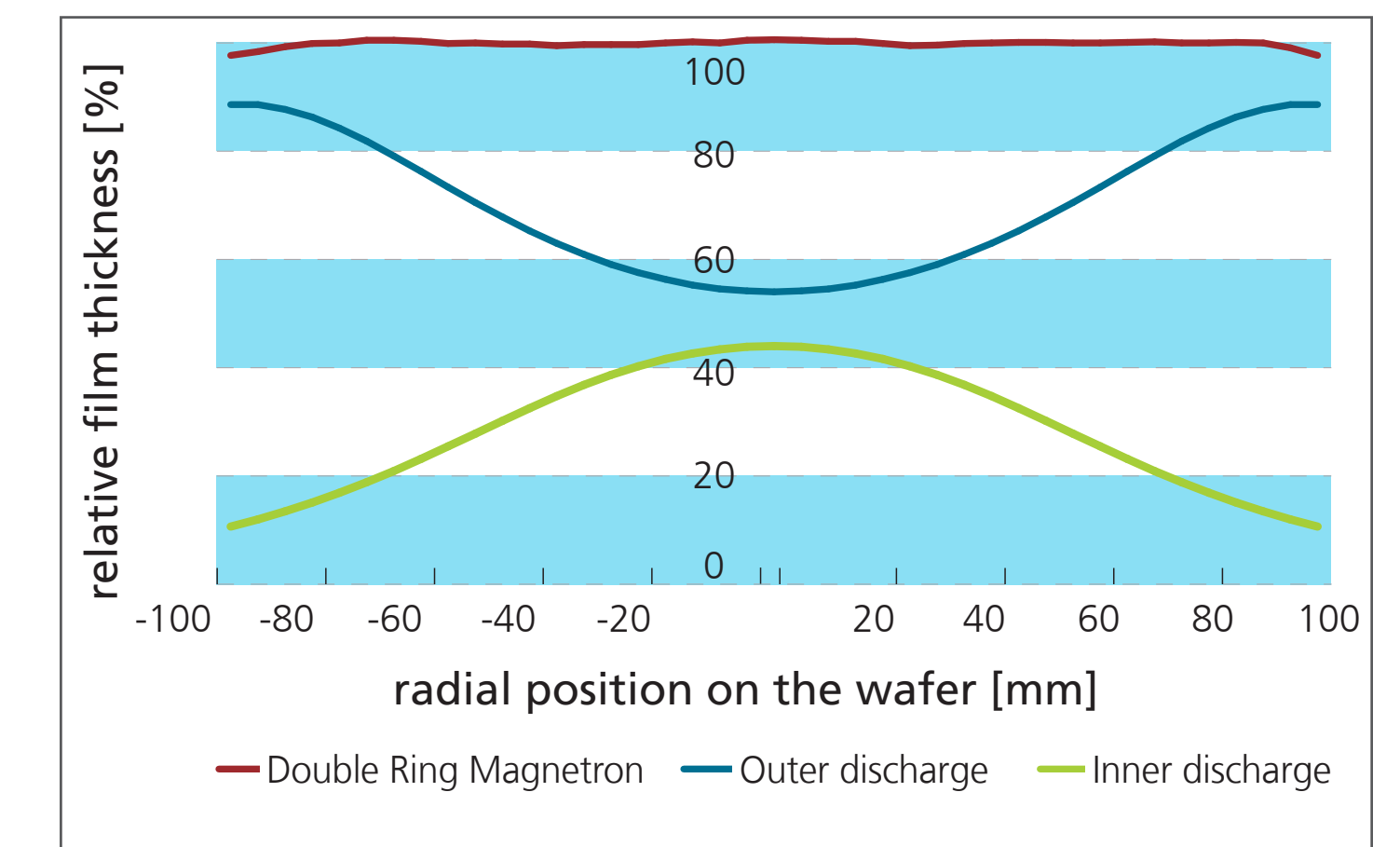
REQUIREMENTS

- high breakdown field strength,
- high insulation resistivity,
- high area yield,
- high piezoelectric coefficient,
- resistance to aggressive media,
- effective permeation barriers,
- good adaptation of the coefficients of expansion to the substrate
- temperature stability
 - 200°C for application in process control for injection molding
 - 400°C measurements in the combustion chamber
 - 600°C measurements in the exhaust line of combustion engines
 - 800°C for turbine applications

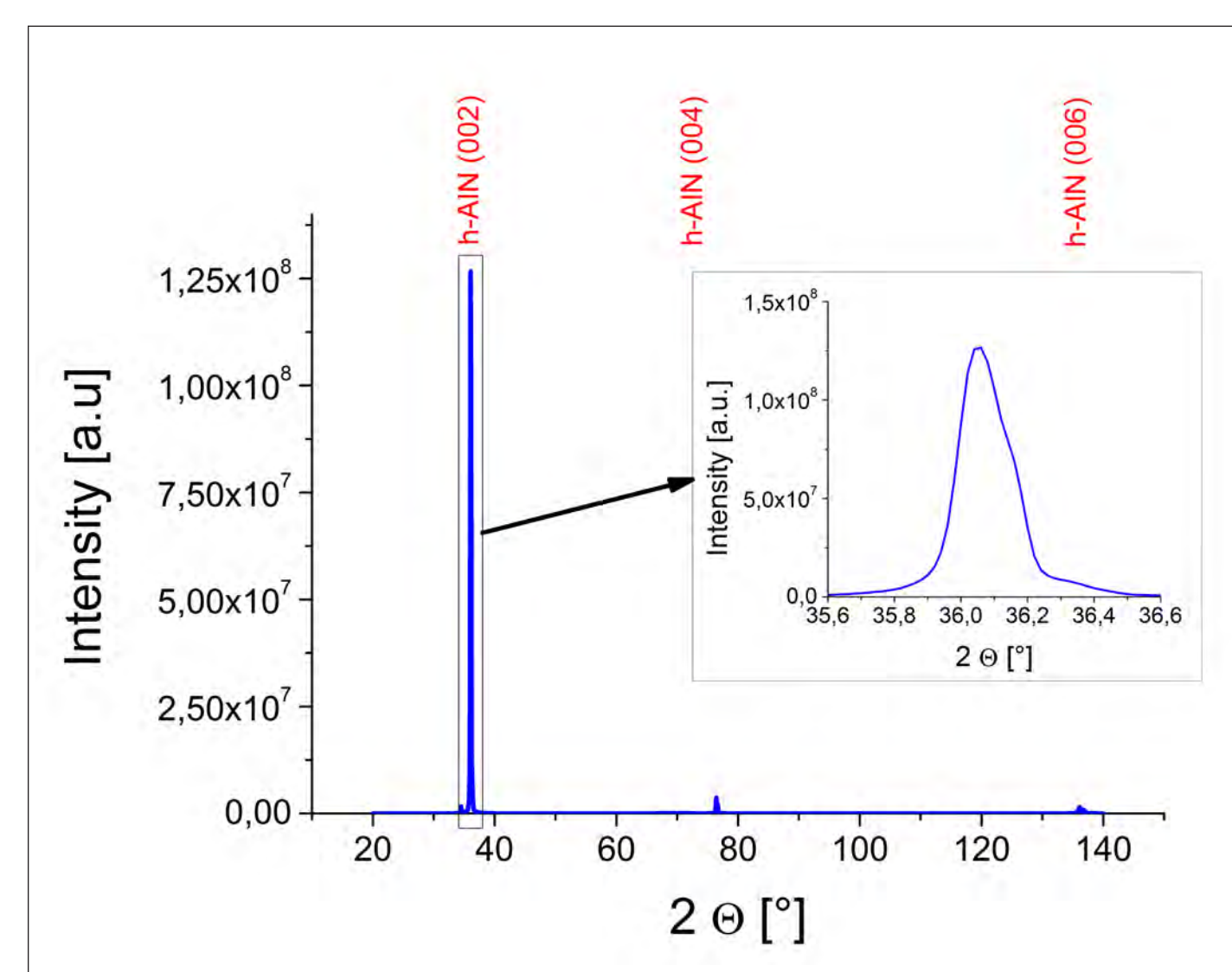
DEPOSITION TECHNOLOGY

- Double Ring Magnetron DRM 400
- film thickness uniformity: up to $\pm 0.5\%$ on 8" substrate by stationary coating
- reactive sputtering from metallic target using closed loop reactive gas control
- unipolar and bipolar pulse sputtering in the mid-frequency range (50 kHz)
- deposition rate of dielectric films 80 ... 250 nm/min

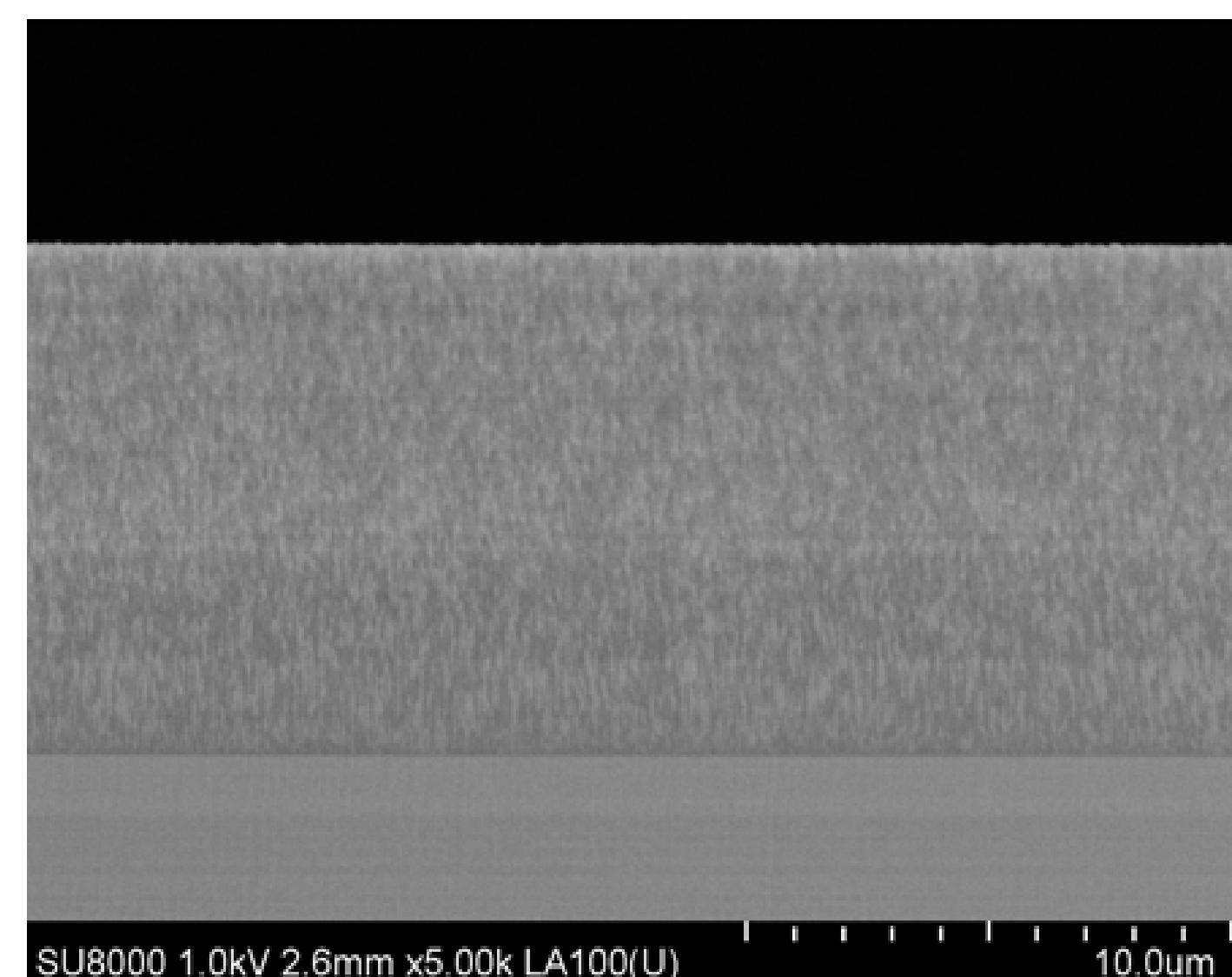
Double Ring Magnetron DRM 400 for uniform coating of $\varnothing 200$ mm (8") substrates



PIEZOELECTRIC AlN AND AlScN FILMS



XRD of AlN film



SEM of AlScN film

Material	Thickness [μm]	d_{33} [pm/V]	P_{RMS} (5 μm excitation) [μW]	Power density [mW/cm^3]
AlN	10	7	70	15.0
	50	7	141	6.4
AlScN	10	29	350	74.0

Generated power for micro energy harvesting with AlN and AlScN films

APPLICATIONS OF PIEZOELECTRIC AlN FILMS

- energy harvesting
- ultrasonic microscopy with phased array sensors
- pipe surveillance
- BAW components
- temperature stability 1100°C

ELECTRICALLY INSULATING Al₂O₃, SiO₂ AND Si₃N₄ FILMS

Material	Deposition rate [nm/min]	Resistivity [$\Omega \times \text{cm}$]	Break down field strength [MV/cm]
SiO ₂	250	$6,3 \times 10^{16}$	5.6
Al ₂ O ₃	150	$2,3 \times 10^{16}$	6.2
Si ₃ N ₄	80	$5,2 \times 10^{13}$	2.4

Deposition rate and insulation properties of Al₂O₃, SiO₂ and Si₃N₄ films, measured at room temperature on silicon wafer, film thickness 1 μm

Al₂O₃, SiO₂ AND Si₃N₄ AS BARRIER FILMS

Material	Film thickness [nm]	Water vapor transmission rate [g/m ² d]	Oxygen transmission rate [cm ³ /m ² d bar]
PET foil		7.9	
SiO ₂	200	0.1	<0.1
Si ₃ N ₄	50	0.12	<0.1
Al ₂ O ₃	200	0.022	<0.1

Water vapor transmission rate (WVTR) and Oxygen transmission rate (OTR) of SiO₂, Si₃N₄ and Al₂O₃ films on 75 μm PET

SUMMARY

- high rate deposition of AlN, Al₂O₃, Si₃N₄ and SiO₂ films
- good insulation strength also at an operation temperature of 400°C
- high piezoelectric coefficient of AlN
- improvement of thermal stability of Al₂O₃ by 5% SiO₂ content
- high permeation barrier of the films

CORRESPONDING CONTACT

Fraunhofer-Institut für Elektronenstrahl- und Plasmatechnik FEP

Winterbergstraße 28
01277 Dresden, Germany

www.fep.fraunhofer.de

Dr. Hagen Bartzsch
hagen.bartzsch@fep.fraunhofer.de

Phone +49 351 2586 390
Fax +49 351 258655 390



Corresponding Contact

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