



# ***XLDS-15***

## **Magnetic Resonance Crosslink Density Spectrometer**

XLD Measurements within Seconds

Elastomer/Polymer  
Quality Assurance

Optimization of Rubber Curing

Aging of Rubbers

Contract Research

Consulting



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# Predictive Elastomer Testing - QC/QA

## Measurement of XLD within Seconds

The chemical and physical properties of cured elastomers are mainly determined by the structure and density of crosslinks. Consequently, crosslink density and its uniformity is a major parameter for quality control and quality assurance of rubber products. The **IIC XLDS-15** Crosslink Density Spectrometer enables the accurate measurement of the crosslink density within minutes without chemical sample modification. The determination of the crosslink density is based on the measurement of the molecular dynamics of the hydrocarbon chain protons using the magnetic resonance principle.

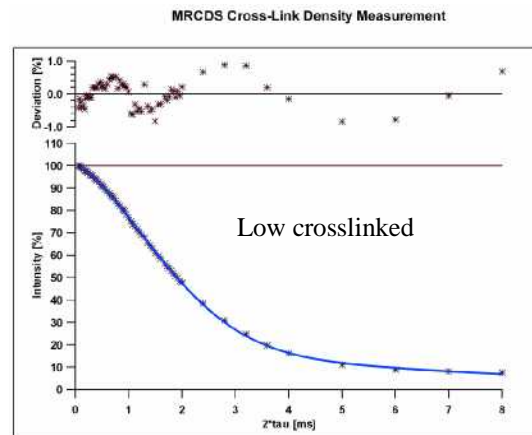
### Applications:

- ? Quality assurance and quality control in development and production of elastomers
- ? Optimization of curing conditions
- ? Follow up the time course of curing processes
- ? Predictive testing of rubber parts
- ? Investigation and characterization of aging processes
- ? Measurement of moisture and solvents in rubbers, epoxy resins, ceramics, concrete and semiconductor devices
- ? Characterization of Gel/Latex-Systems
- ? Determination of liquids and solid phases

### Advantages:

- ? Designed for routine use in rubber testing and R&D lab's
- ? Fully automatic and/or manual measurement of crosslink density of rubbers, silicon elastomers and resins
- ? Fully automatic data analysis
- ? Short measurement times ( approx. 5 min.)
- ? Very high accuracy (SDEV typ. about 5 %.)
- ? Excellent reproducibility (SDEV typ. 2 %.)
- ? No special sample preparation
- ? Sample preparation free of chemicals
- ? User friendly system and software
- ? Very low operating expenses

Crosslink density of differently crosslinked, unfilled and filled rubber samples, for comparison measured using the **IIC MR-CDS 3500**, swelling and Mooney-Rivlin methods (Courtesy of Dr. S. Kelbch, BayerAG, Leverkusen)



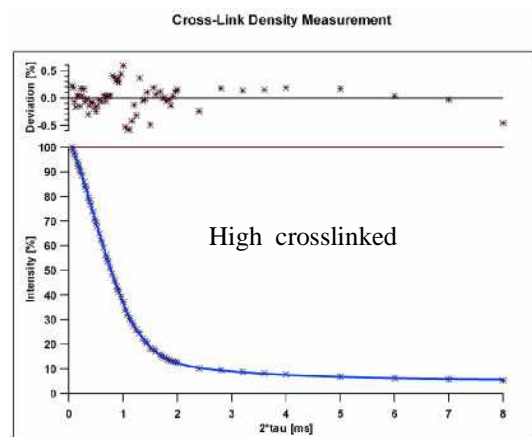
MR-CDS Data Analysis

Cross-Link Density =  $(3.17 \pm 0.11) \cdot 10^{-5} \text{ mol/cm}^3$   
 $M_c = (14.51 \pm 0.01) \text{ kg/mol}$   $AM_c = 76.27 \%$   
 Var. Coeff. = 13.51 %

$T_2 = (6.32 \pm 0.26) \text{ ms}$   $AT_2 = 25.37 \%$   
 Var. Coeff. = 14.06 %

$qM_2 = (0.32 \pm 0.01) \cdot 10^{-7} \text{ s}^{-2}$   
 $M(0) = -0.22 \%$   
 $SDEV = 10.32042$   
 $\tau$ -Values = 64  
 SNR = 1929.27

Sample: Bayer K150  
 Files: K150\_1.dat, Bayer.tb  
 Date: 3/7/00, Time: 10:59:53



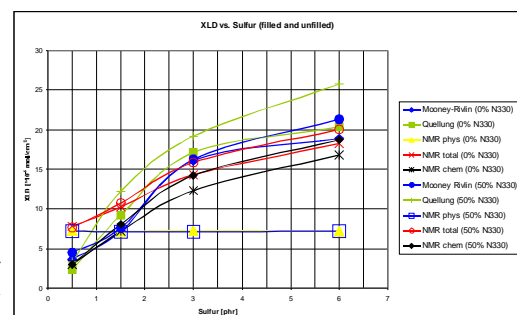
MR-CDS Data Analysis

Cross-Link Density =  $(7.22 \pm 0.11) \cdot 10^{-5} \text{ mol/cm}^3$   
 $M_c = (6.37 \pm 0.03) \text{ kg/mol}$   $AM_c = 81.55 \%$   
 Var. Coeff. = 11.51 %

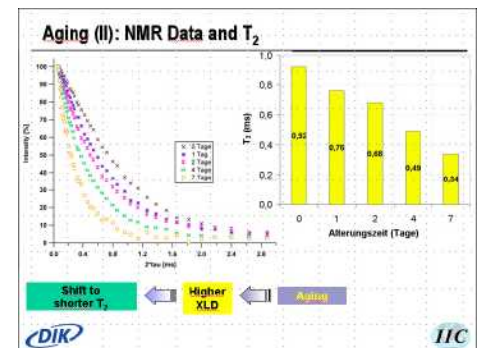
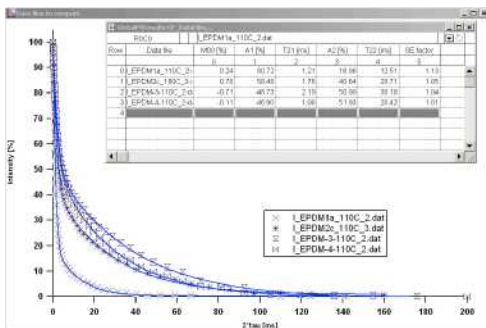
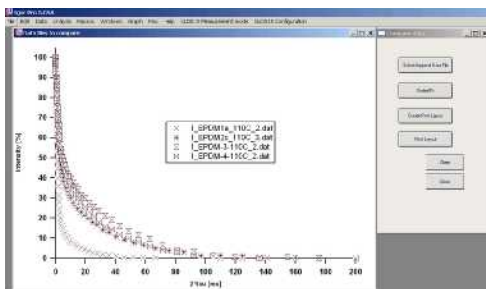
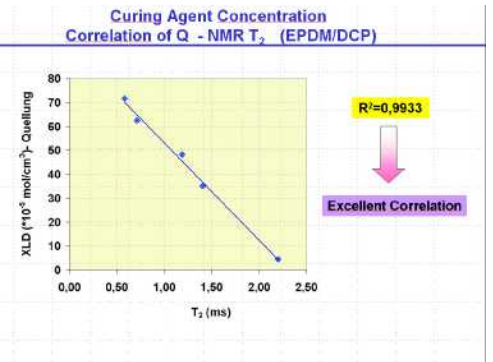
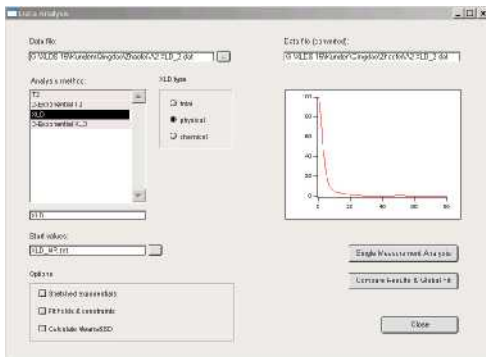
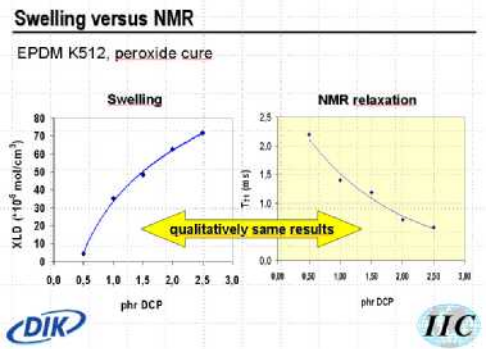
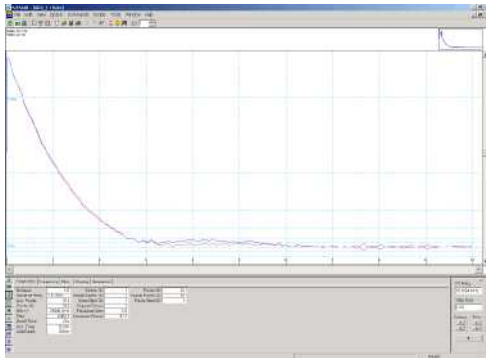
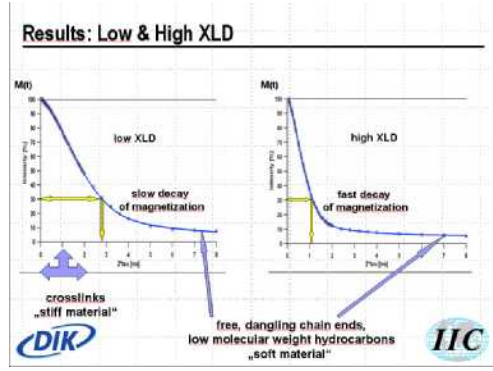
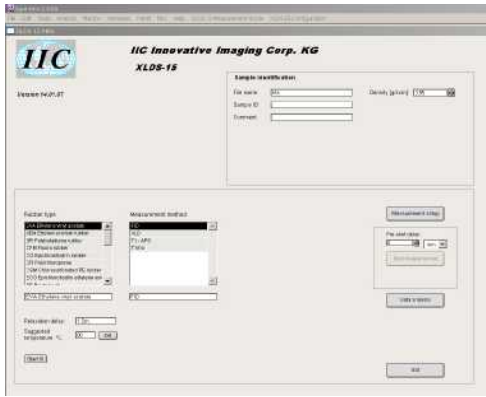
$T_2 = (2.00 \pm 0.04) \text{ ms}$   $AT_2 = 15.88 \%$   
 Var. Coeff. = 11.85 %

$qM_2 = (1.66 \pm 0.03) \cdot 10^{-6} \text{ s}^{-2}$   
 $M(0) = 5.46 \%$   
 $SDEV = 3.77091$   
 $\tau$ -Values = 64  
 SNR = 1578.91

Sample: Bayer K153  
 Files: K153\_1.dat, Bayer.tb  
 Date: 3/7/00, Time: 11:06:47



# IIC XLDS-15 User Interface & Results



Depending on selected measurement mode (R&D or QA/QC), most of measurements and data analysis are already pre-configured and do not need any further settings by operator.

**System Specifications(Selection):**  
 ØMagnetic field strength 0.35 Tesla(15MHz)  
 ØTwo Mode Operation:  
 1.Fully Automatic, incl. data analysis  
 2.Research Mode, all parameters accessible by user  
 ØXLD, T1, mono- and multiexponential T2, T1ρ, T1D

# IIC XLDI-100

## High Resolution MRI System for Materials Imaging



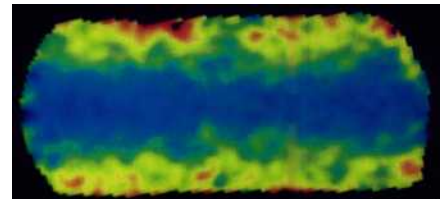
The measurement principle of the *MRXLDI-100* is similar to the clinical application of MRI, but provides the spatially resolved determination of materials parameters on the molecular scale.

### Advantages:

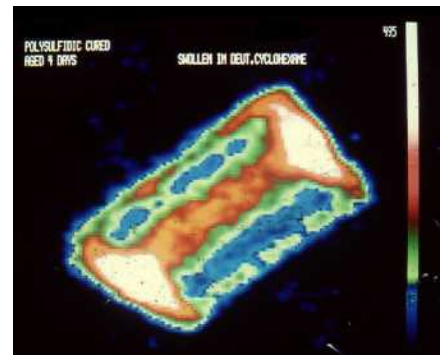
- ? 2D-, 3D-Imaging of materials parameters (MAPI *Materials Parameter Imaging*)
- ? Visualization of molecular dynamics
- ? Easy to use
- ? Designed for use in quality control and R&D lab's.

### Applications:

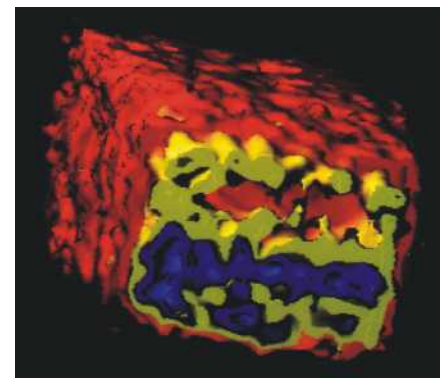
- ? Spatially resolved determination of crosslink density and other materials parameters
- ? Predictive testing on Elastomers, Polymers, and Ceramics
- ? Nondestructive investigation of aging processes in elastomers
- ? Spatially and time resolved monitoring of ingress of liquids into solid matrices
- ? Mapping of diffusion coefficients and diffusion anisotropy



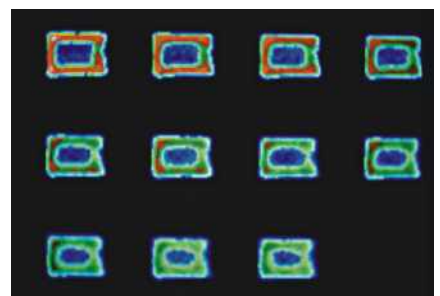
Aging of rubbers: T<sub>1</sub>-MAP-Image of a sulfur cured sample, aged for 4 days at 90°C



Aging of rubbers: NMR-Image of a sulfur cured sample, aged for 4 days at 90°C, swollen in deuterated Cyclohexane



Distribution of moisture in a semiconductor chip based on an epoxy resin matrix



Time course of solvent penetration into a rubber sample



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