Micro spectroscopy of crystals Wave

# A line of high-frequency EPR/ODMR spectrometers operating at W and D bands

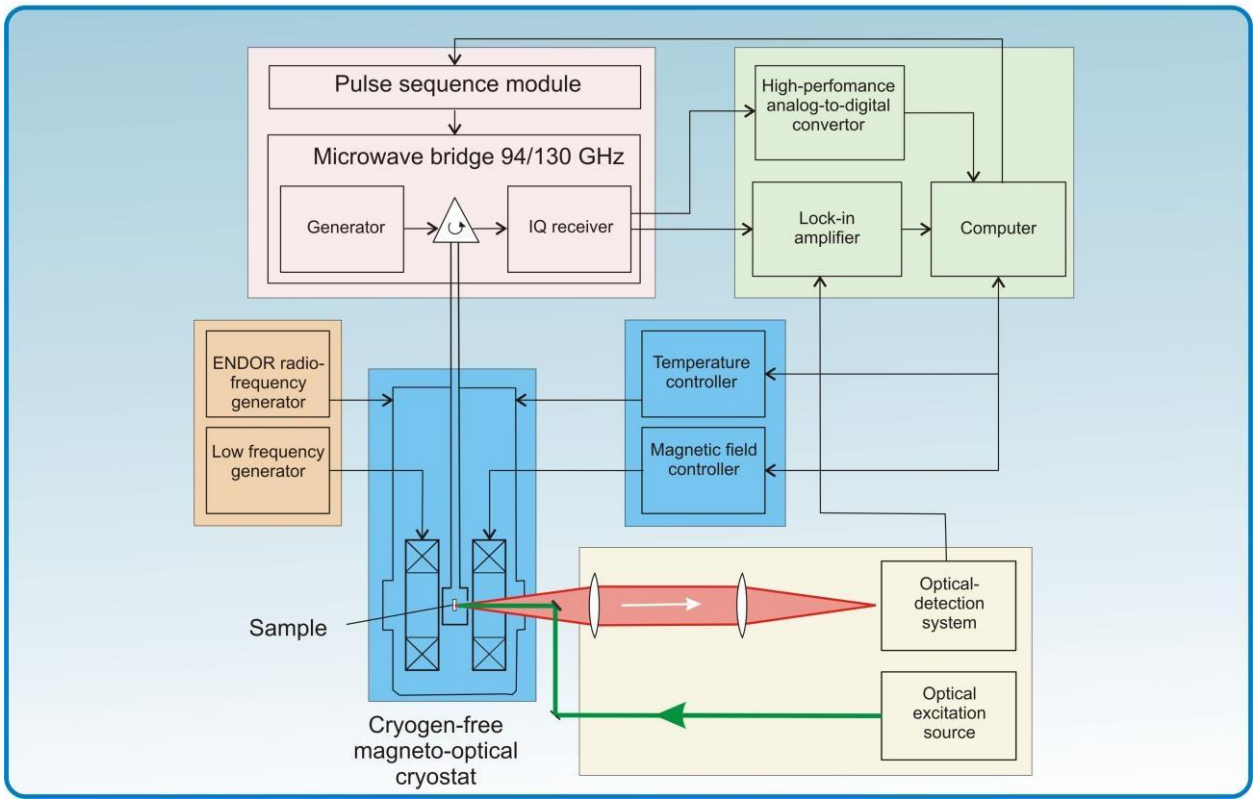
**Electron paramagnetic resonance (EPR)** was discovered by Zavoisky in Kazan (1944) and turned into the powerful analytical methods available today for physicists, chemists, biologists. Over the next seventy five years, EPR and related EPR methods have played a decisive role in the study of spin phenomena in condensed matter: semiconductors, dielectrics, biophysical objects, living systems; proved to be the most informative tools for non-destructive diagnostics the structural properties of atomic and molecular objects at the electronic level.

## Advantages of high-frequencies and double resonance techniques

- high sensitivity;
- approachability sensitivity in ODMR $10^3$-$10^2$ spins up to single spin;
- high spectral resolution of the EPR and ENDOR;
- high resolution of the anisotropic properties;
- the ability to study systems with large zero-field splitting;
- the achievement of high Boltzmann factors;
- high spectral resolution in cyclotron resonance;
- suppressing higher-order effects, etc.

## Applications of EPR/ODMR

- non-destructive diagnostics of condensed matters;
- research and control of materials promising for applications in photovoltaics;
- spin manipulation in spintronics and quantum information technologies, devices based on nanostructures, single quantum objects;
- analysis of geological rocks;
- study of the nature of photosynthesis, biological processes, metal-proteins; free radicals;
- development of new types of drugs;
- the use in dosimetry, etc.



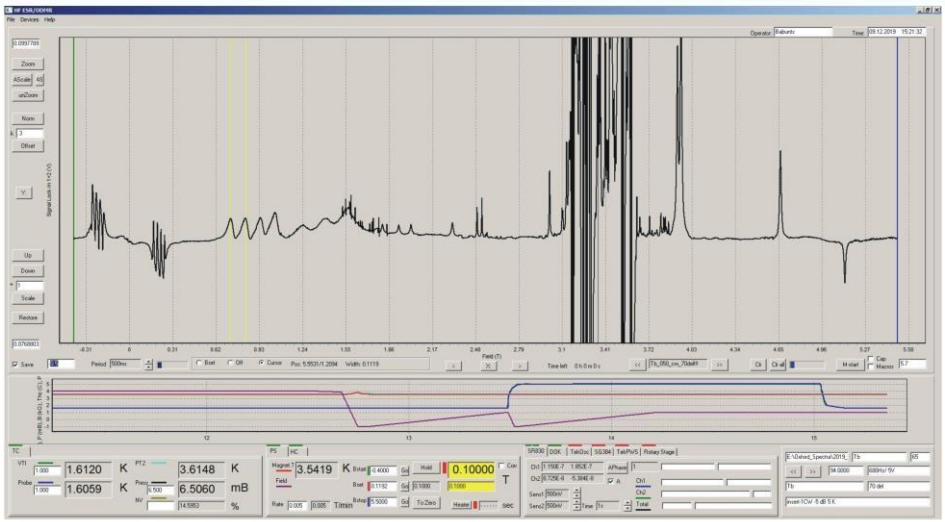
## Technical Specification

| | |
|---|---|
| Operating modes | CW, Pulse, Photo-EPR, ODMR, LAC, ENDOR |
| Microwave power insert | Nonresonant system or resonator |
| Key Features | Optical access, orientation dependence, modulation of the magnetic field or microwave frequency |
| Cryostat | Closed-circle magneto-optical cryostat |
| Magnetic field, T | -7 - +7 |
| Energisation rate, T/min | 0.1 – 0.001 |
| Operating temperature range, K | 1.5 – 300 |
| Insert space diameter, mm | 30 |

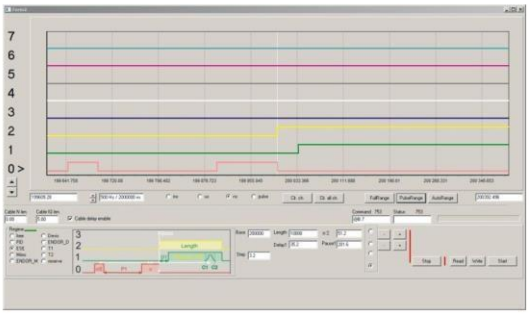
| Microwave bridge | W | D |
|---|---|---|
| Fix. generator, GHz | 94 | 130 |
| Var. generator, GHz | 94±0.25 | 130±0.25 |
| Power, mW | 100 | 50 |
| Attenuator, dB | 40 | 40 |
| Pulse duration, ns | 10 – 100 000 000 | |
| Step (Delay-Resolution), ns | 3.2 | |
| Repetition rate, Hz | 0.1 – 10 000 | |
| Number of channels | 8 | |

## Benefits

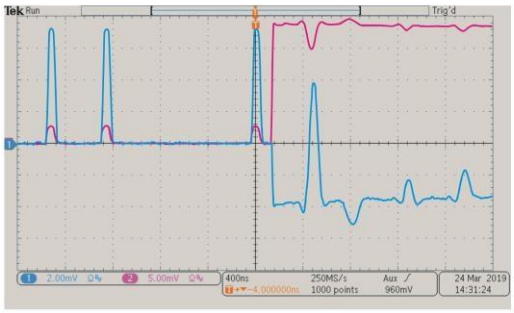
- Unified schemes for 94 and 130 GHz
- Extremely stable generator
- Low phase noise (narrow spectrum)
- High output power
- Sensitive super-heterodyne IQ receiver
- Pulse sequence formation
- Compact bridges, close to cryostat
- Closed-circle magneto-optical cryostat
- Split-coil superconductive magnet with induction from -7 to +7 T
- Sample temperature from 1.5 to 300 K
- Optical access provided by 4 windows
- Compact, low cost, flexible
- Remote control



The control and data acquisition of spectrometer in CW and pulse modes are carried by the special program

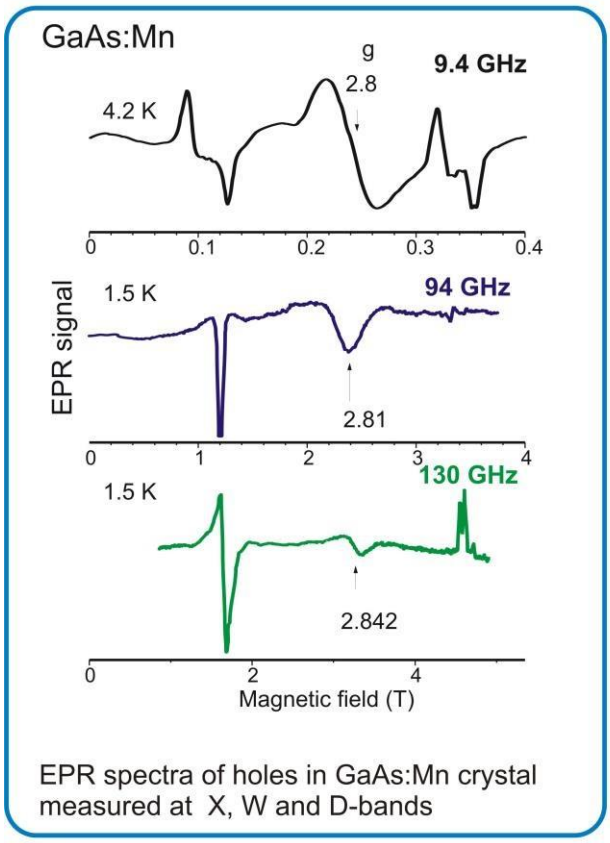


A window for set up the pulse sequence

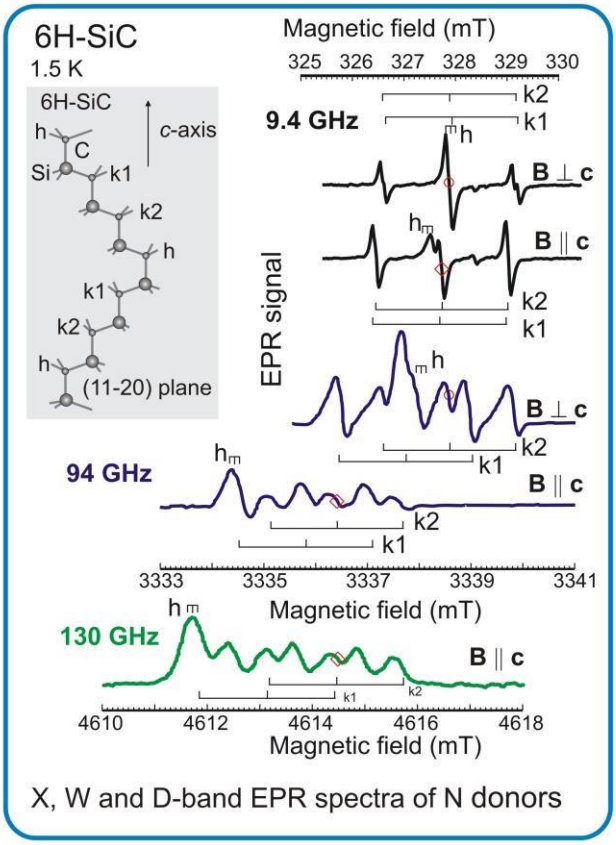


A stimulated echo

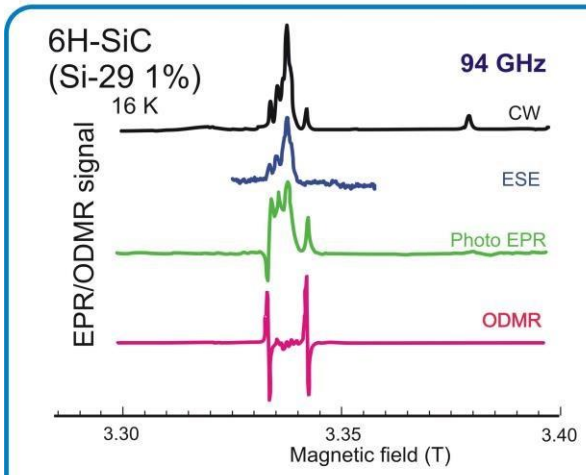
# Application examples

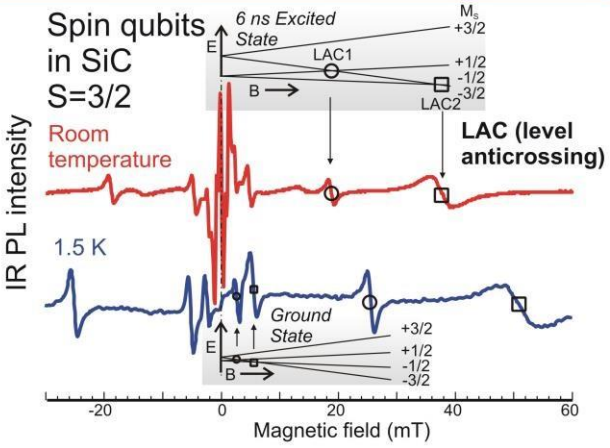



EPR spectra of holes in GaAs:Mn crystal measured at X, W and D-bands



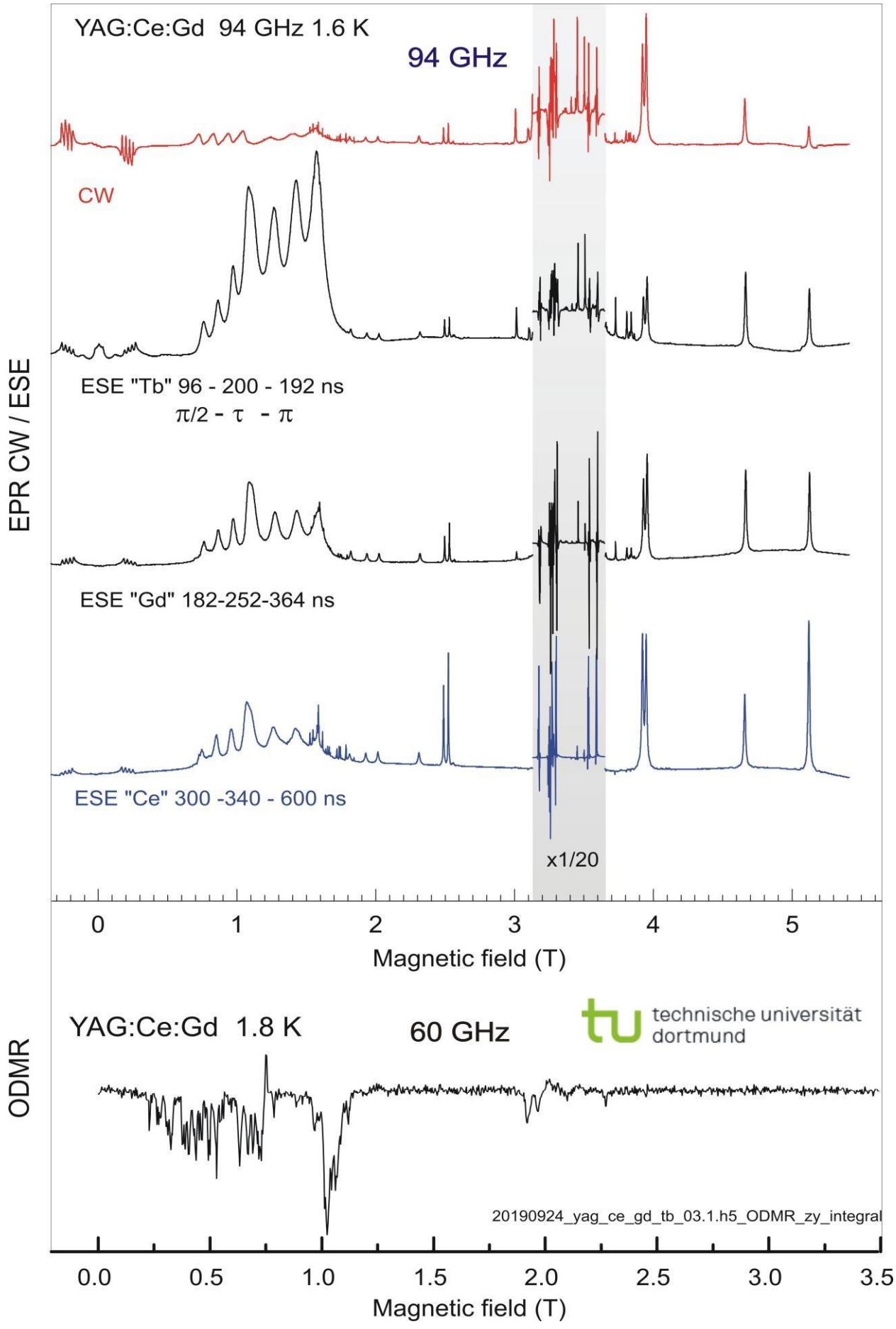

X, W and D-band EPR spectra of N donors




Continuous-Wave EPR, ESE, photo EPR, ODMR and LAC spectra

# Microwave bridges of 2 mm and 3 mm bands were developed



YAG:Ce:Gd 94 GHz 1.6 K
94 GHz
CW
ESE "Tb" 96 - 200 - 192 ns
π/2 - τ - π
ESE "Gd" 182-252-364 ns
ESE "Ce" 300 -340 - 600 ns
x1/20
EPR CW / ESE
0
1
2
3
4
5
Magnetic field (T)
YAG:Ce:Gd 1.8 K
60 GHz
technische universität
dortmund
ODMR
20190924_yag_ce_gd_tb_03.1.h5_ODMR_zy_integral
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Magnetic field (T)