Nonequilibrium carrier dynamics in undoped and Ce-doped GaGG

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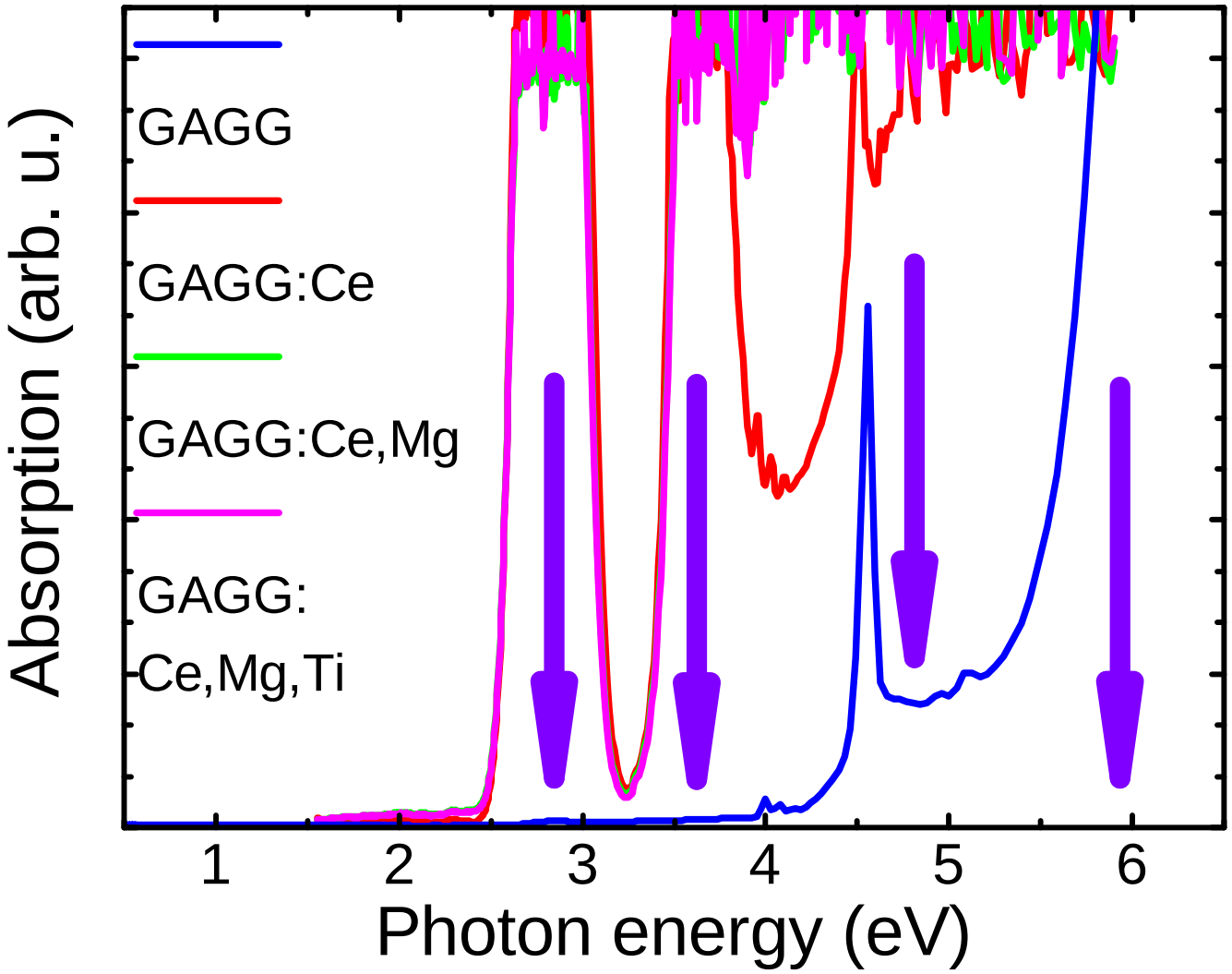
Outline

- ❑ Samples under study
- ❑ Nonequilibrium carrier absorption
  - Experimental technique
  - Results
  - Numerical modeling
- ❑ Conclusions

Samples under study



Experimental techniques

Nonlinear light absorption

OPA "ORPHEUS"
630-1020 nm/1040-2600 nm
(SH 320-500)

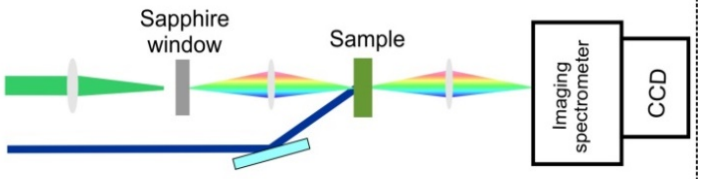
"PHAROS"
Yb:KGW
1030 nm
200 fs
6W@30kHz

SHG

Delay stage

Pump

$$\frac{I_{TR}(with.pump)}{I_{TR0}(without.pump)} = \exp\{-\int_0^d \Delta\alpha(\lambda, z, t)dz\}$$

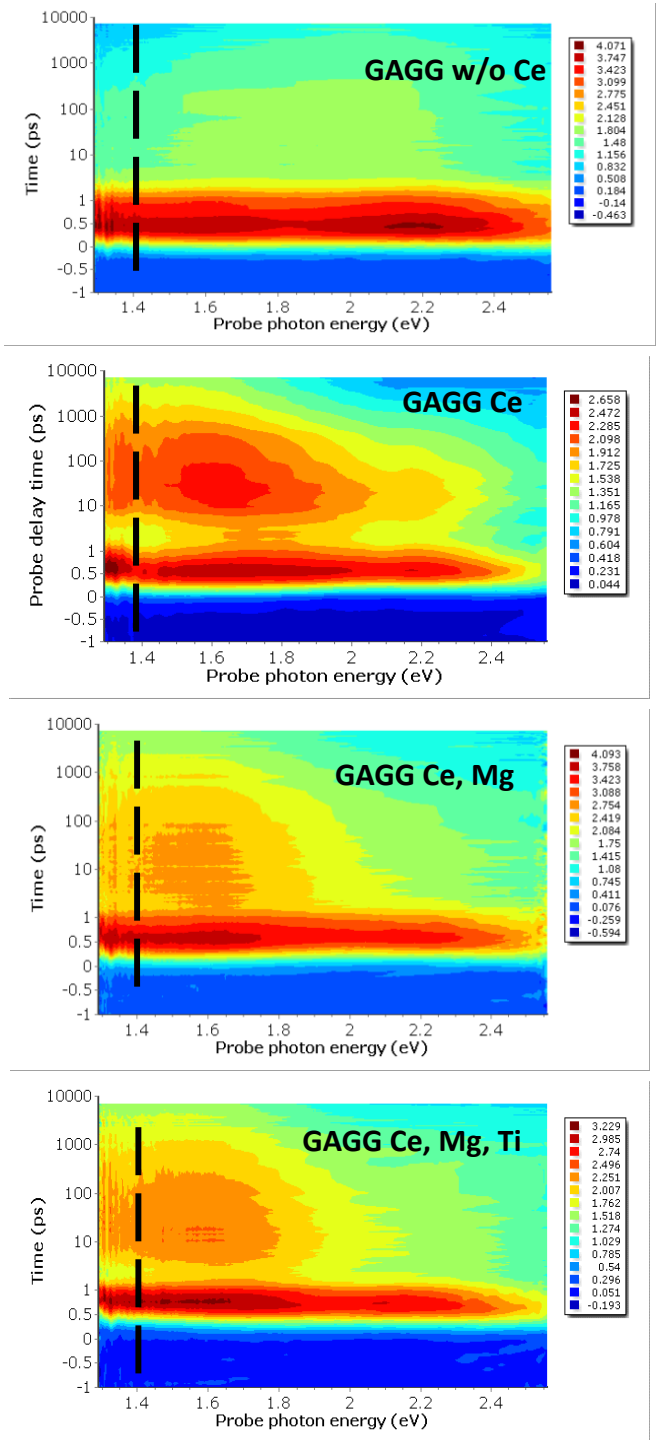


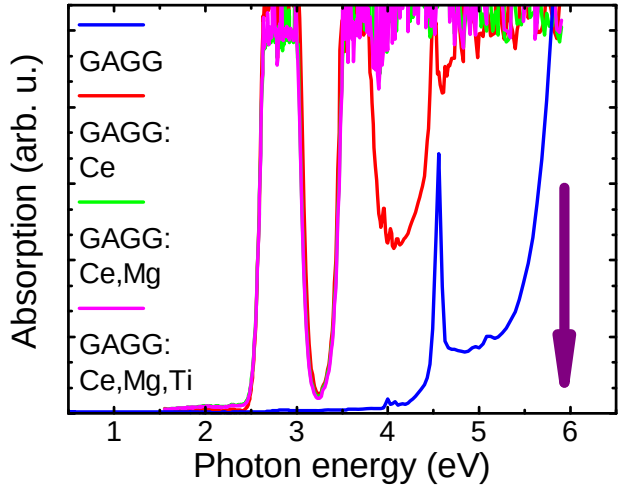
Probe:
460-950 nm (2.7- 1.3eV)

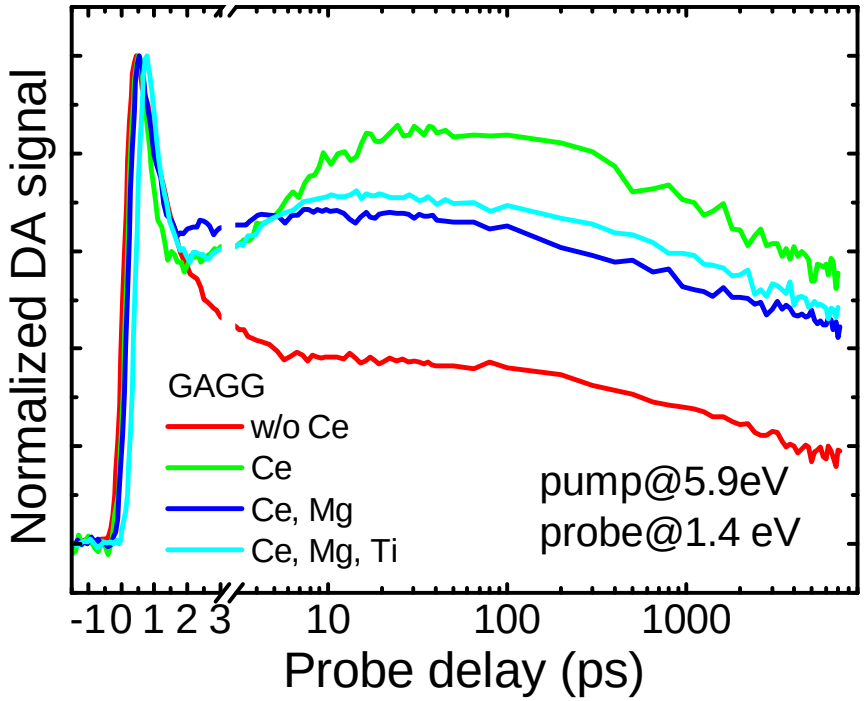
Excitation (pump):

- **210 nm (5.91 eV)**
- **258 nm (4.81 eV)**
- **342 nm (3.63 eV)**
- **443 nm (2.80 eV)**

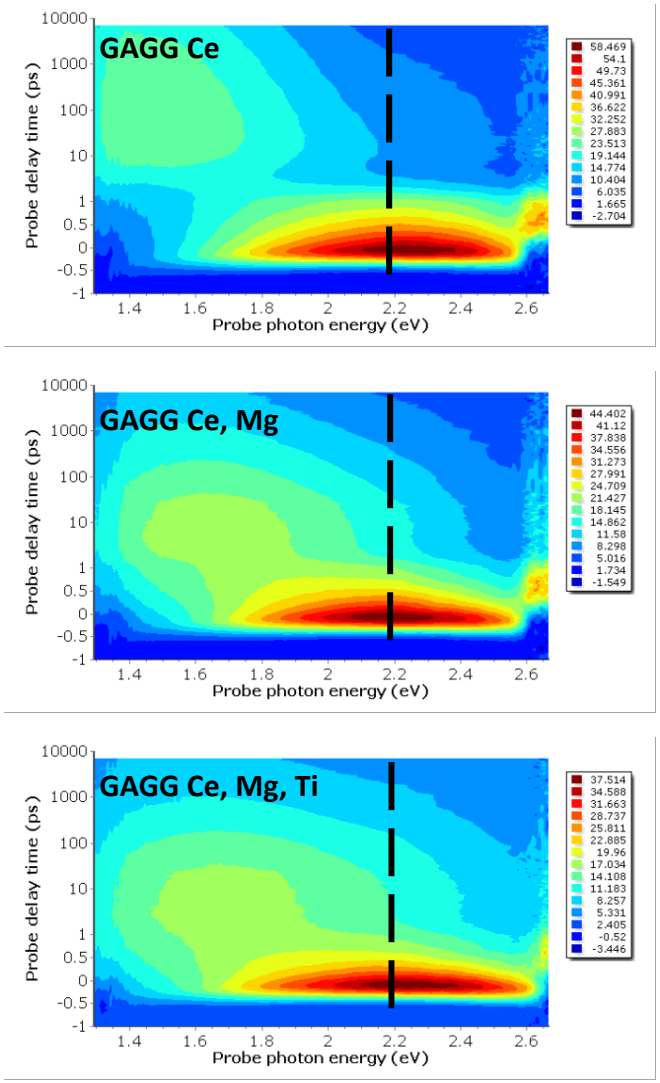
5.9 eV pump

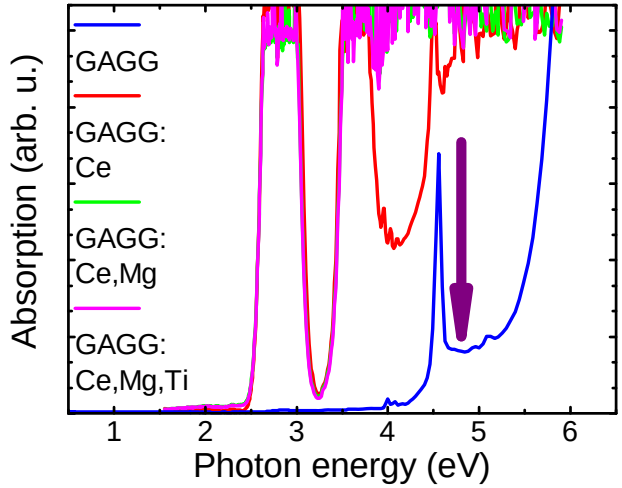

GAGG w/o Ce
Time (ps)
Probe photon energy (eV)
GAGG Ce
Probe delay time (ps)
Probe photon energy (eV)
GAGG Ce, Mg
Time (ps)
Probe photon energy (eV)
GAGG Ce, Mg, Ti
Time (ps)
Probe photon energy (eV)

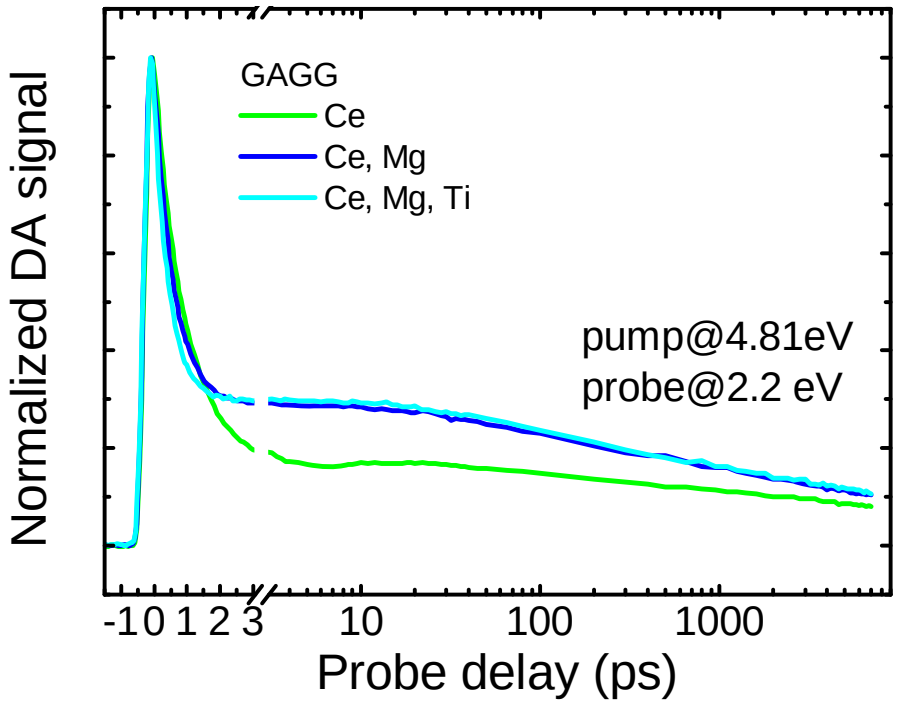

GAGG
GAGG: Ce
GAGG: Ce,Mg
GAGG: Ce,Mg,Ti
Absorption (arb. u.)
Photon energy (eV)


GAGG
w/o Ce
Ce
Ce, Mg
Ce, Mg, Ti
pump@5.9eV
probe@1.4 eV
Normalized DA signal
Probe delay (ps)

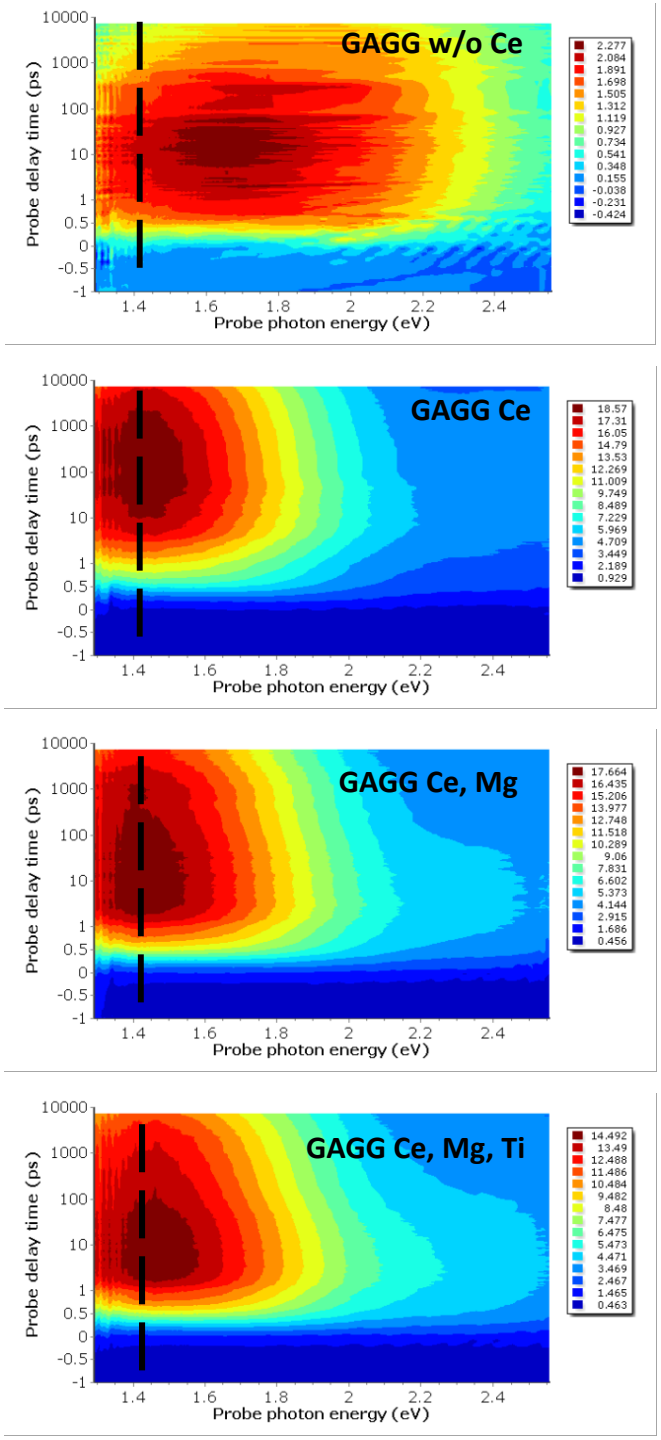
4.8 eV pump

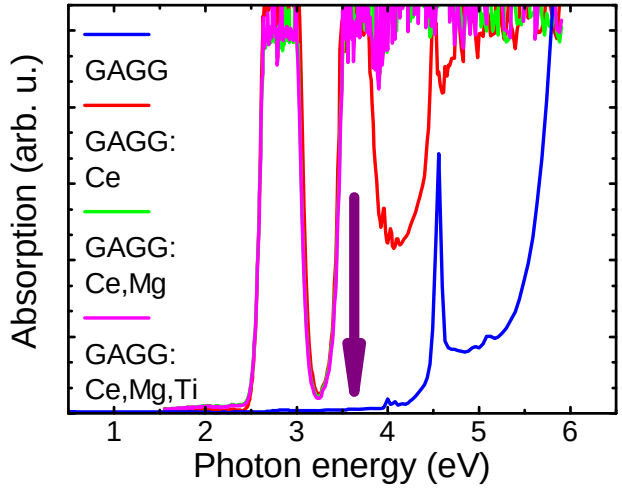

GAGG Ce
GAGG Ce, Mg
GAGG Ce, Mg, Ti
Probe delay time (ps)
Probe photon energy (eV)

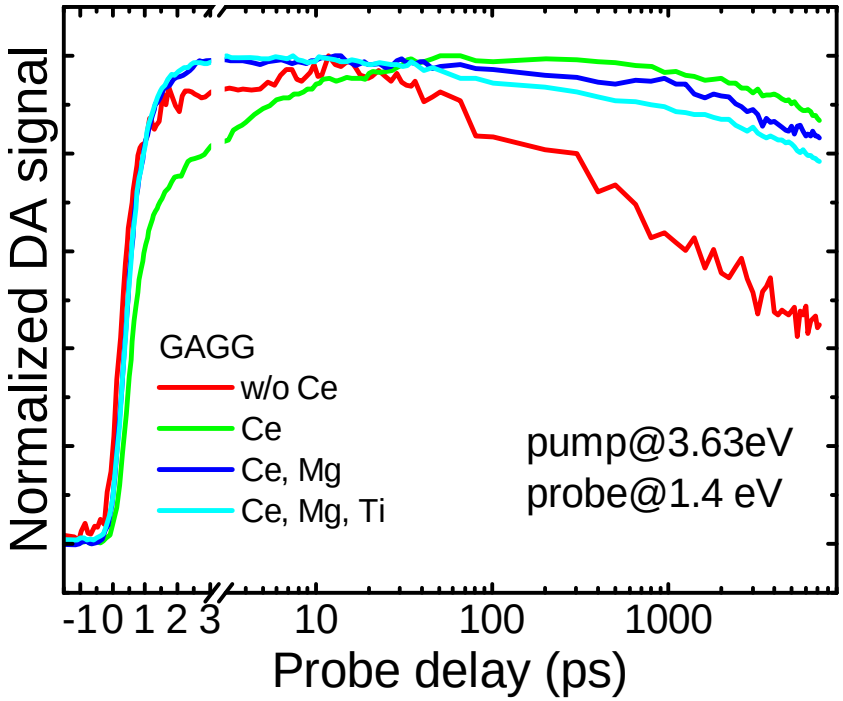

GAGG
GAGG: Ce
GAGG: Ce,Mg
GAGG: Ce,Mg,Ti
Absorption (arb. u.)
Photon energy (eV)


GAGG
Ce
Ce, Mg
Ce, Mg, Ti
pump@4.81eV
probe@2.2 eV
Normalized DA signal
Probe delay (ps)

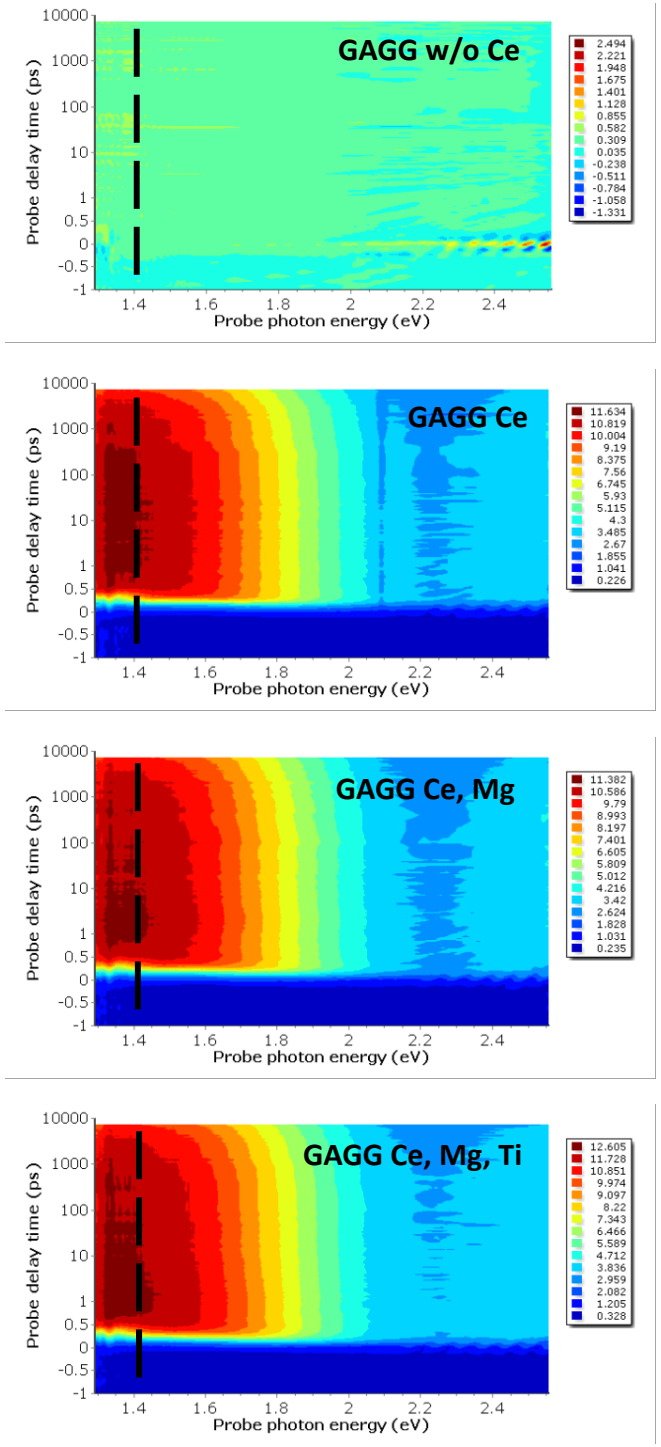
3.6 eV pump

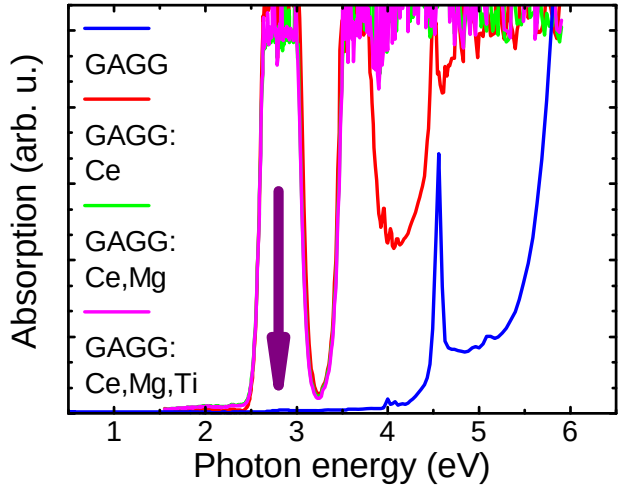

GAGG w/o Ce
GAGG Ce
GAGG Ce, Mg
GAGG Ce, Mg, Ti
Probe delay time (ps)
Probe photon energy (eV)


GAGG
GAGG: Ce
GAGG: Ce,Mg
GAGG: Ce,Mg,Ti
Absorption (arb. u.)
Photon energy (eV)


GAGG
w/o Ce
Ce
Ce, Mg
Ce, Mg, Ti
pump@3.63eV
probe@1.4 eV
Normalized DA signal
Probe delay (ps)

2.8 eV pump


GAGG w/o Ce
GAGG Ce
GAGG Ce, Mg
GAGG Ce, Mg, Ti
Probe delay time (ps)
Probe photon energy (eV)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GAGG: Ce
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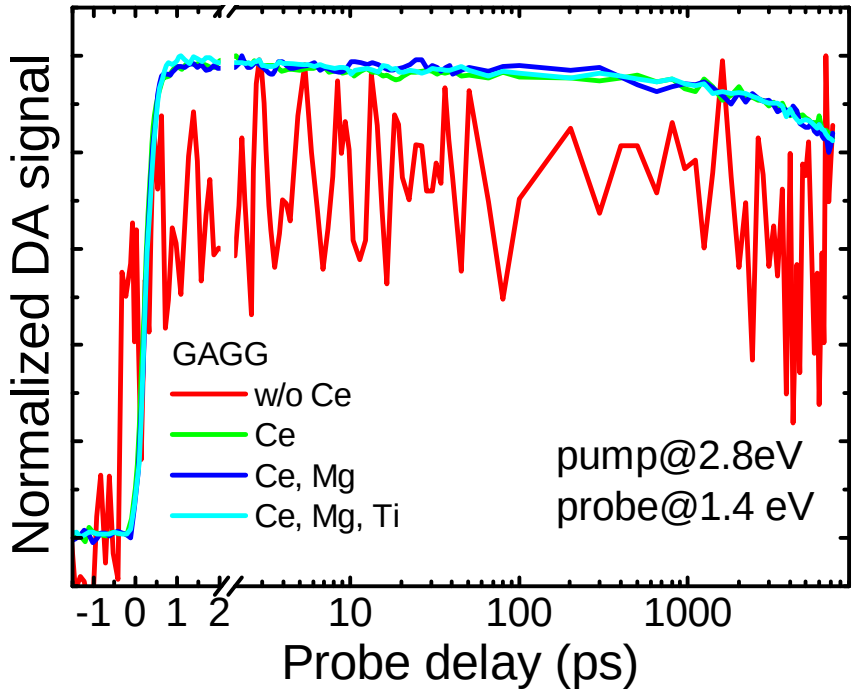
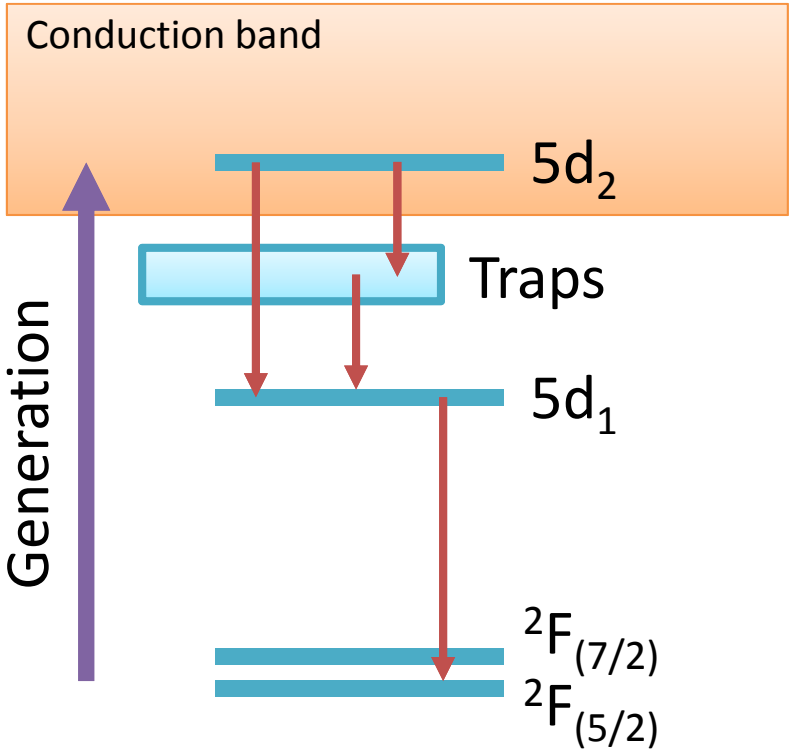
Absorption (arb. u.)
Photon energy (eV)

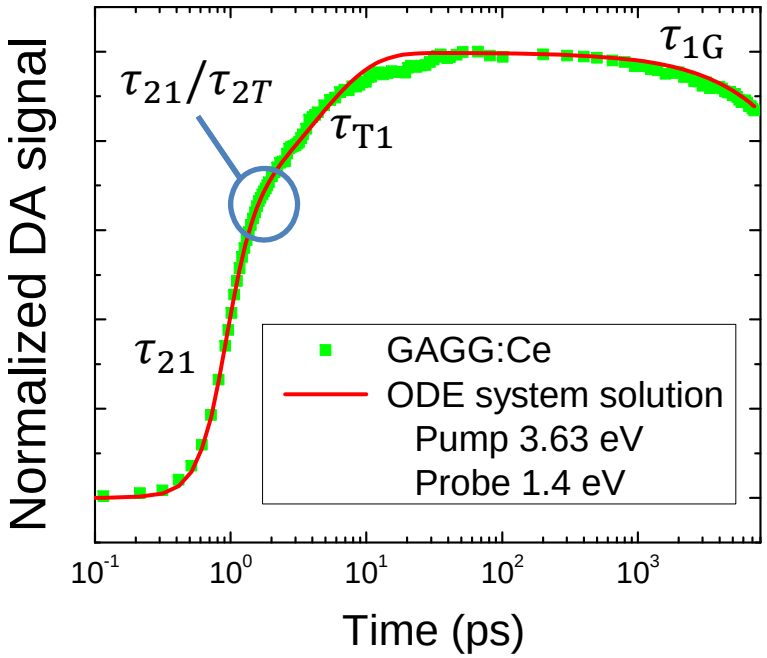

GAGG
w/o Ce
Ce
Ce, Mg
Ce, Mg, Ti
pump@2.8eV
probe@1.4 eV
Normalized DA signal
Probe delay (ps)

Electron relaxation numerical model



$$\begin{cases} \dfrac{dN_{5d2}}{dt} = G(t) - \dfrac{N_{5d2}}{\tau_{21}} - \dfrac{N_{5d2}}{\tau_{2T}} \\ \dfrac{dN_T}{dt} = \dfrac{N_{5d2}}{\tau_{2T}} - \dfrac{N_T}{\tau_{T1}} \\ \dfrac{dN_{5d1}}{dt} = \dfrac{N_{5d2}}{\tau_{21}} + \dfrac{N_T}{\tau_{T1}} - \dfrac{N_{5d1}}{\tau_{1G}} \end{cases}$$

Sample	τ_{21} ps	τ_{2T} ps	τ_{T1} ps	τ_{1G} ns
Ce	0.52	1.05	4.09	56
Ce, Mg	0.52	11.77	1.43	32
Ce, Mg, Ti	0.52	89.27	1.00	24



Conclusions

- Photons with energies above 4.8 eV excite gadolinium atoms in GAGG; the excitation decays within picoseconds.
- Charge carrier dynamics in selectively excited cerium ions in GAGG:Ce ar not affected by co-doping.
- Co-doping with magnesium reduces the influence of indirect electron transfer thought the crystal matrix to cerium ions.

Thank you for your attention

The collaboration has been facilitated by

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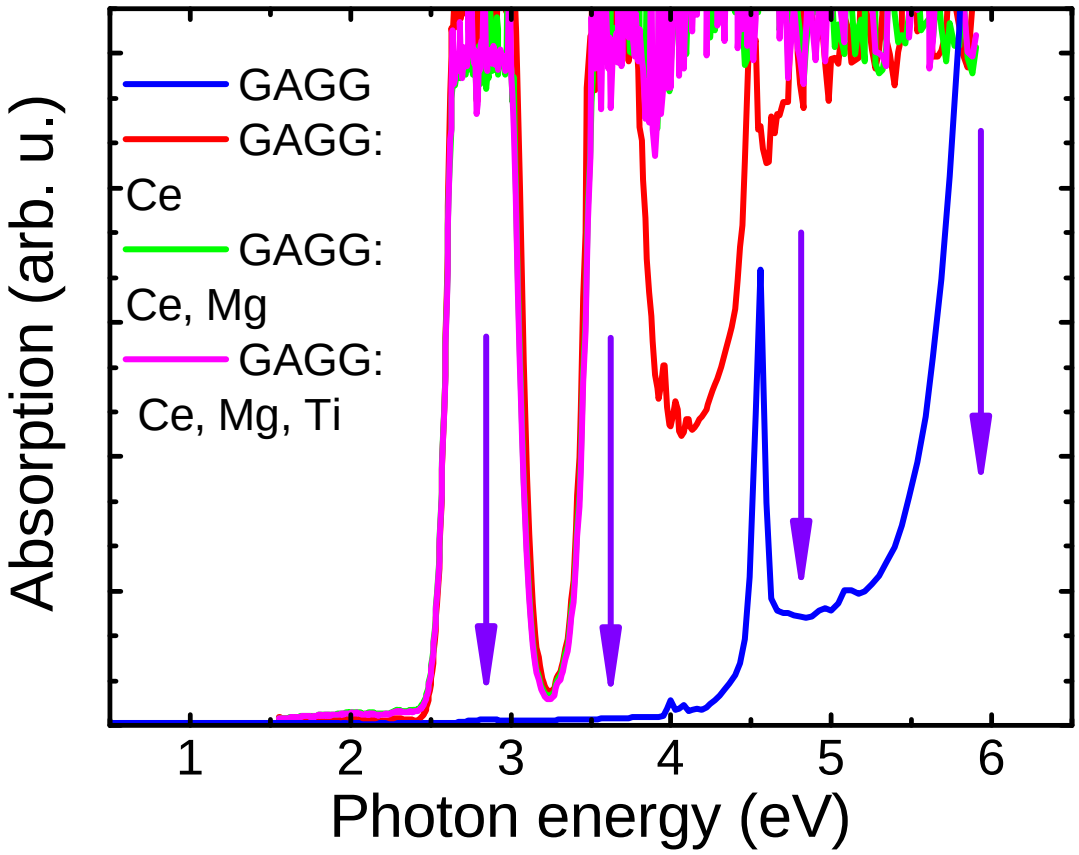
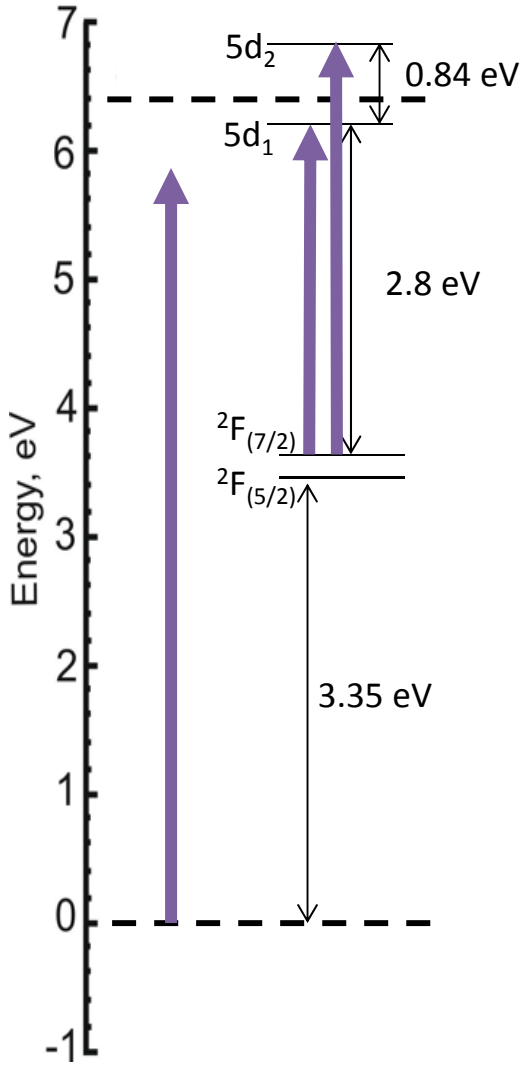
Samples under study



Ce^{3+}