RD-50 Vilnius 4.05 – 6.05.2007

Kinetic studies for n-irradiated Si with enhanced carbon concentration

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OUTLINE

- Motivation
- Experimental details:
  - measurement technique,
  - sample preparation,
  - annealing processes
- Experimental results
- Approximation of the experimental data by a first order diffusion limited model
- Fitting procedure by a multi-reaction model
- Results of fitting procedures
- Summary

Motivation

To find out how the carbon concentration affects the kinetics of annihilation and generation of the main oxygen related complexes VO and VO_2 in neutron irradiated silicon

Experimental details

Sample preparation:

- **Silicon 2 mm thick wafers were cut from n and p type CZ-Si and n type FZ-Si crystals with different carbon concentration.**
- **Oxygen concentration for CZ-Si crystals was 9.5-12*10^{17}at/cm^2**
- **Calculation of O and C concentrations from FTIR absorption measurements individually for each wafer before irradiation with taking into account its radial distribution.**
- **Irradiation with the neutron dose of 1*10^{17} n/cm^2**
- **Cutting the wafers into samples of dimension 8x12x2mm^3**
- **Calculation O and C concentrations individually for each sample after irradiation**

Heat treatment

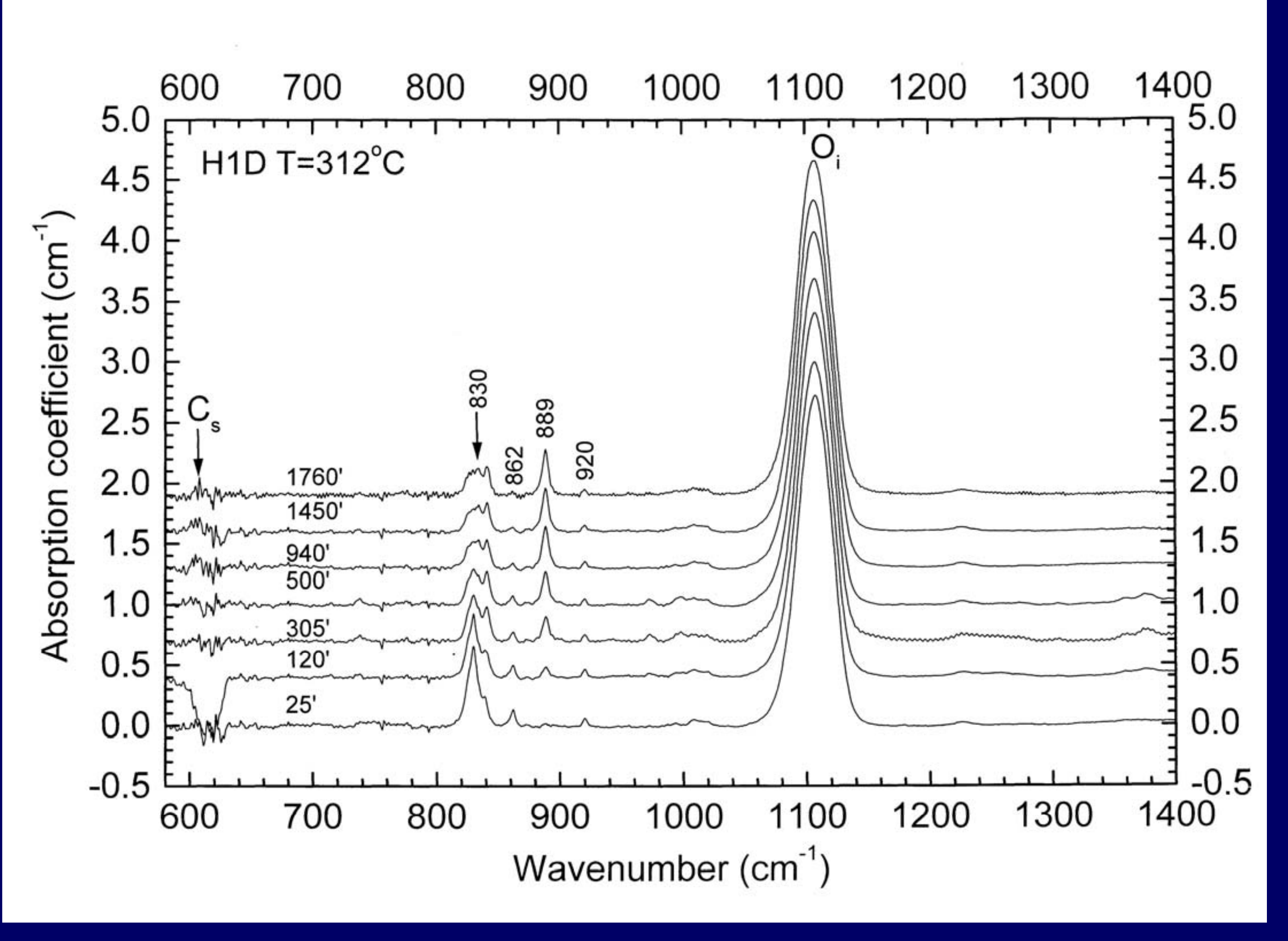
- **Isothermal annealings at 300°C, 312°C, 325°C, 330°C and 350°C for 5- 2000 minutes were performed**
- **After each annealing process the absorption measurements were carried out and concentrations of oxygen and carbon were determined from the intensity of absorption lines at 1107cm-1 an 607cm-1, respectively.**

Basic characteristics of as-grown and as-irradiated wafers

TABLE I Parameters for studied crystals

Dose	crystal	type	resistivity omcm	[O]*10^{17} center	[O]*10^{17} edge	[C]*10^{16}	abs.coeff. VO 831cm^{-1} center	abs. coeff. VO 831cm^{-1} edge	abs. coeff. C_I-O 861 cm^{-1}	D[O] *10^{17} at/cm^{-3} center	D[O] *10^{17} at/cm^{-3} edge	D[C] cent/edge *10^{16} at/cm^{-3}
	HL1			8.77	6.24	1.7-<det	0.576	0.471	0.096-0.086	0.63	1.2	3.3/4.4
	HL2			9.88	8.5	0.58-1.1	0.555	0.515	0.13-0.099	0.36	0.9	3.7/3.3
	HL3			8.7	8.01	-	0.53	0.495	0.035-0.045	1.4	1.2	2.7
neutron irradiated 1*10^{17}n/cm^2	HL4			9.02	8.7	1.09-<det	0.54	0.52	0.07/0.08	0.56	0.9	2/2.4
	HL5			11	10.6	-	0.508	0.517	-	1.3	2.4	<det
	HL6			1.69	1.69	<det	0.253	0.253	0.0219	0.15	0.15	<det
	HL7			-	-	2.18	-	-	-	-		2.6
	L1	n	14	9.4	7.5	5.0-4.9-4.4	-		-			
	L2	p	16	10.24	9.4	4.3	-		-			
	L3	p	8	10.09	9.1	2.75-2.6	-		-			
nonirradiated	L4	p	8	9.58	8.97	3.03/2.4	-		-			
	L5	p	10	12.6	12.4	0.8	-		-			
	L6	n	800	1.84	1.83	1	-		-			
	L7	p	800	-	-	4.85	-		-			

Absorption spectra for sample from H1 crystal versus time of annealing at T=312°C [C]=5*10^{16} at/cm^3 [O]=9.4* 10^{17} at/cm^3



VO - 830cm-1

C_iO_i –862cm-1

VO_2 - 889cm-1

O_i – 1107cm-1

C_s – 607cm-1

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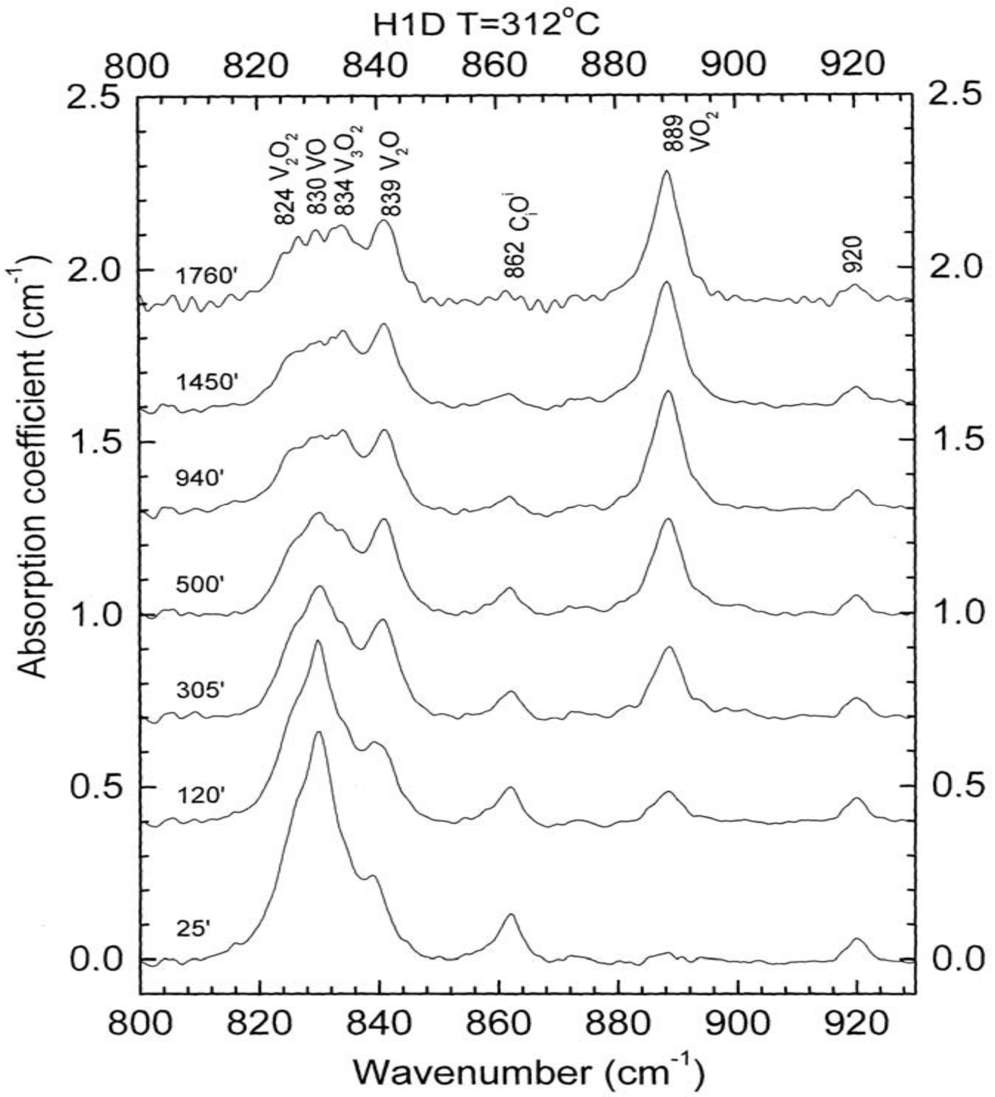


Absorption spectra for oxygen-related defects

VO - 830cm $^{-1}$

C_iO_i - 862cm $^{-1}$

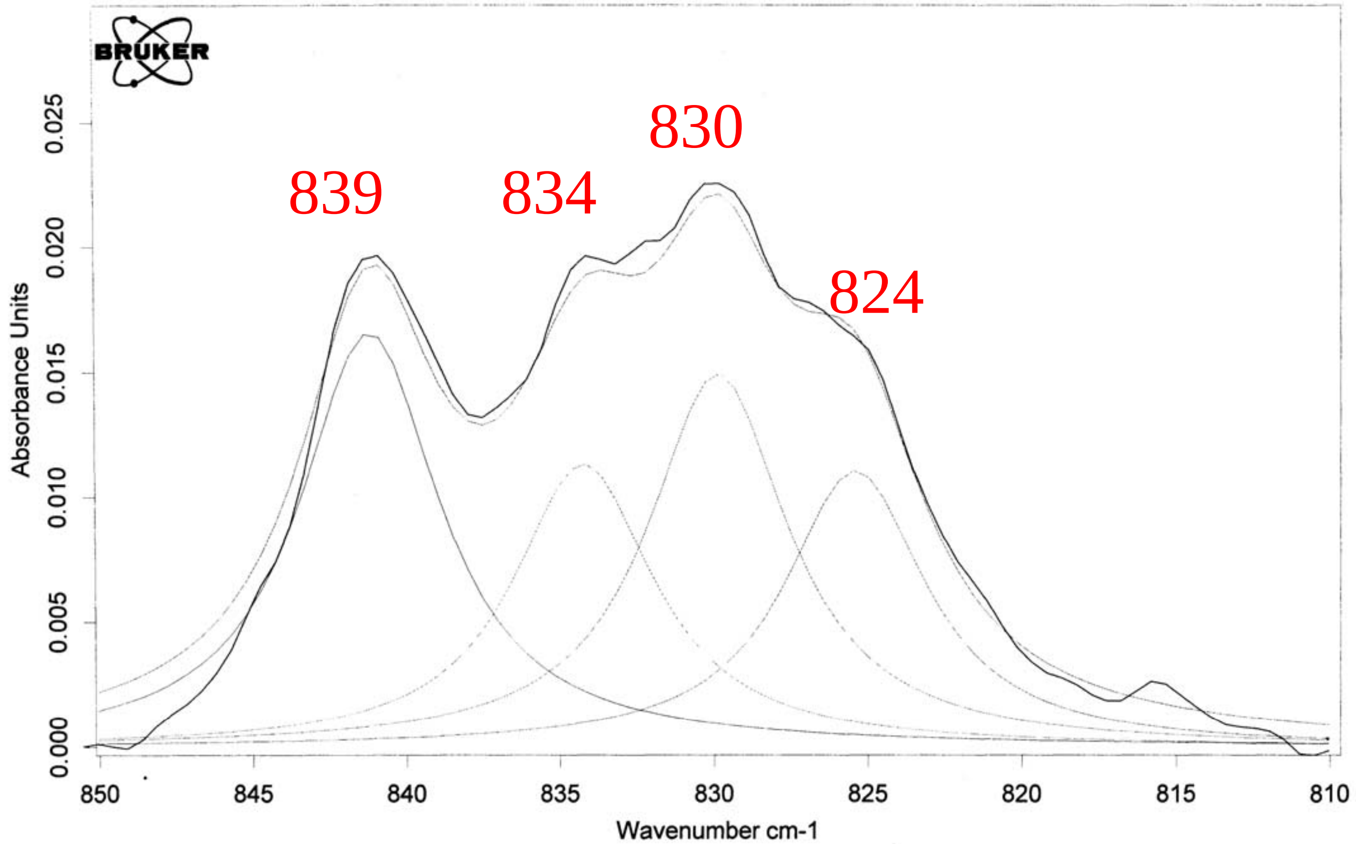
VO_2 - 889cm^{-1}

V_2O - 839cm-^{1}

V_2O_2 – 824cm $^{-1}$

V_3O_2 - 834cm $^{-1}$

Deconvolution



D:\ROMA\Si\Si_irradiated\n-irr_2004\DELTA\wygrzewane\zb_f(czasu)\FIT\T300\H1K\H1K_TX10\BL_H1K_TX10.0	Si-irr 1*10^17n/cm2 TX10=3	2005/03/09
D:\opus\WORK\FIT.1793		18/11/2005
D:\opus\WORK\FIT.1794		18/11/2005
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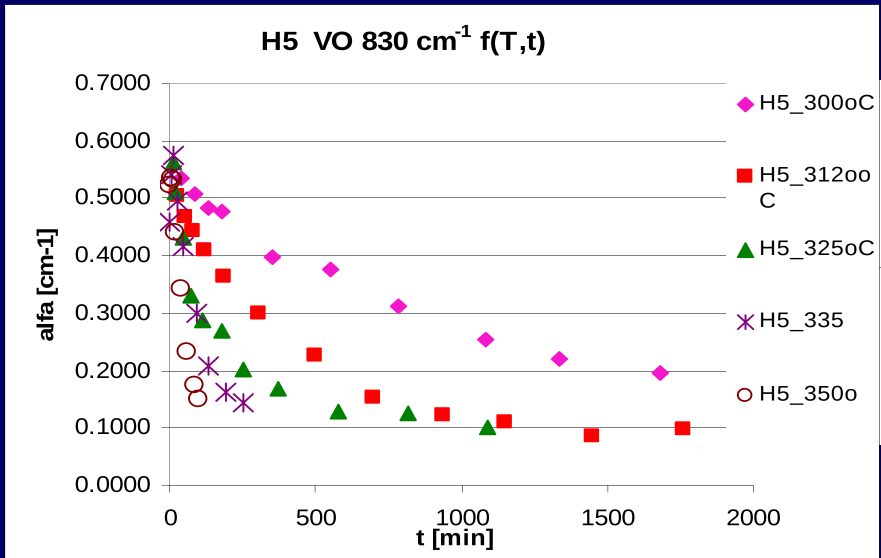
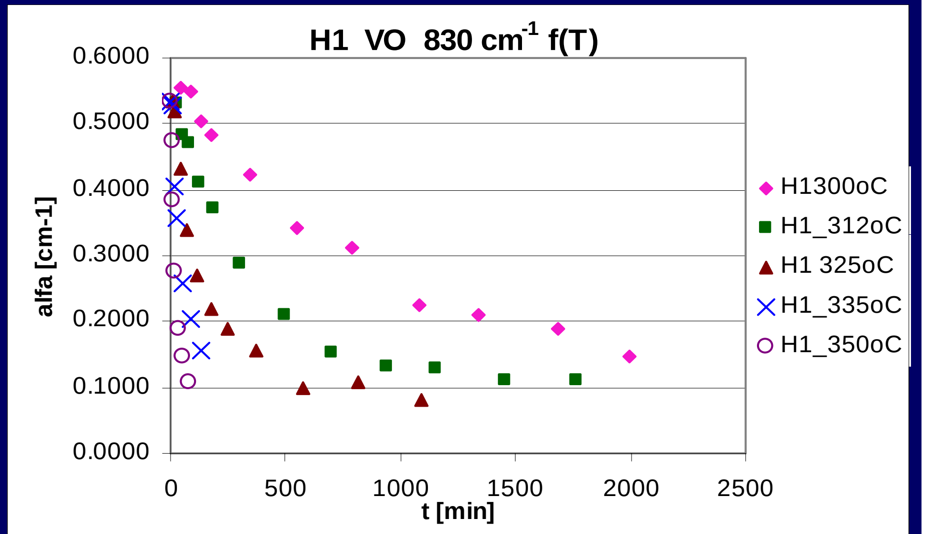
The intensity of the absorption band at 830 cm^{-1} related to VO defects versus time of annealling





[C]=0.8*10^{16} at/cm3

[C]=5*10^{16} at/cm3

Model of diffusion limited processes (1)

The rate equation for defect *N* which disappears through a first-order diffusion-limited processes X+N⟹Z

$$-\partial[N]/\partial t = k * [X]_{t=0} * [N]$$

$$k = 4\pi RD$$

$$D = D_X + D_N$$

R – rate capture radius;
D - diffusion coefficient ;
k -rate constant ;

Model of diffusion limited processes (2)

$$[N] = [N]_{t=0} * \exp(-k\,t)$$

$$k * t = Ln \frac{[N]}{[N]_{t=0}}$$

$$k = k_0 * \exp(-E_a / k_B T)$$

E_a – activation energy for the process

From the temperature dependence of the reaction rate ***k*** the activation energy is determined

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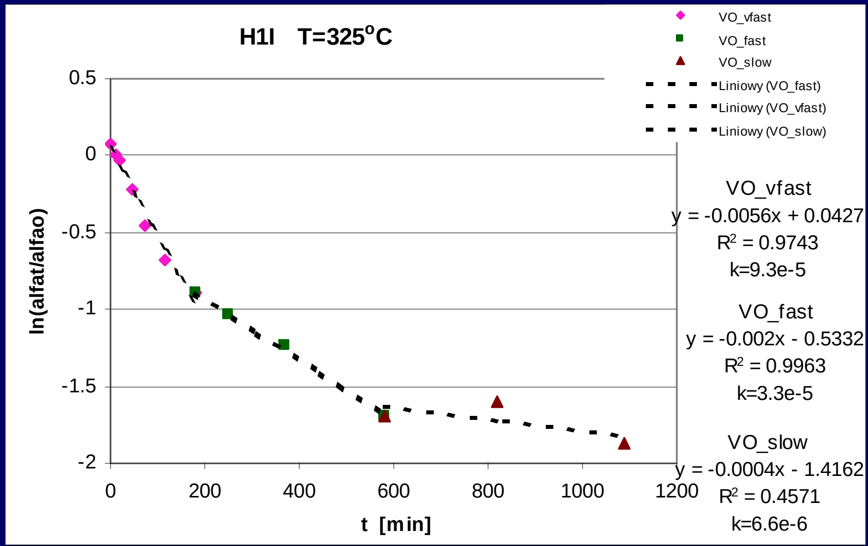
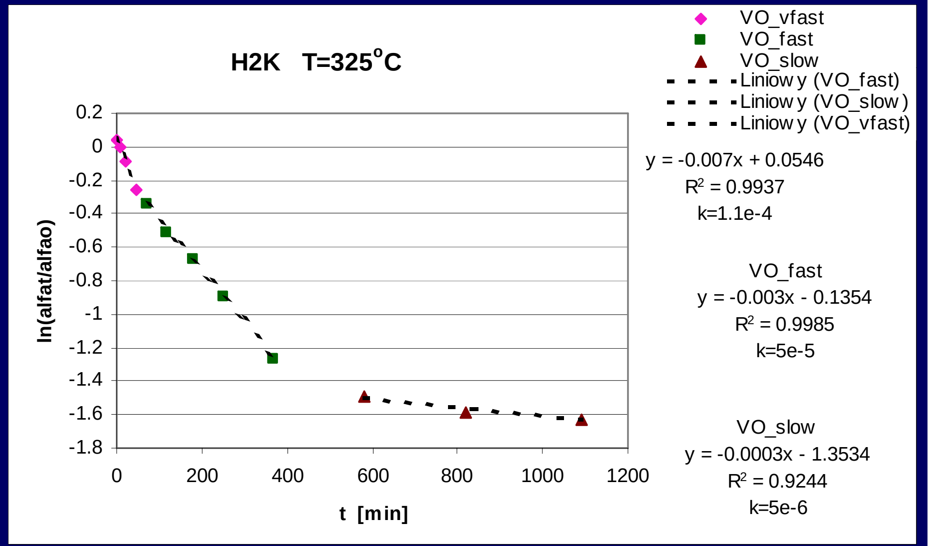
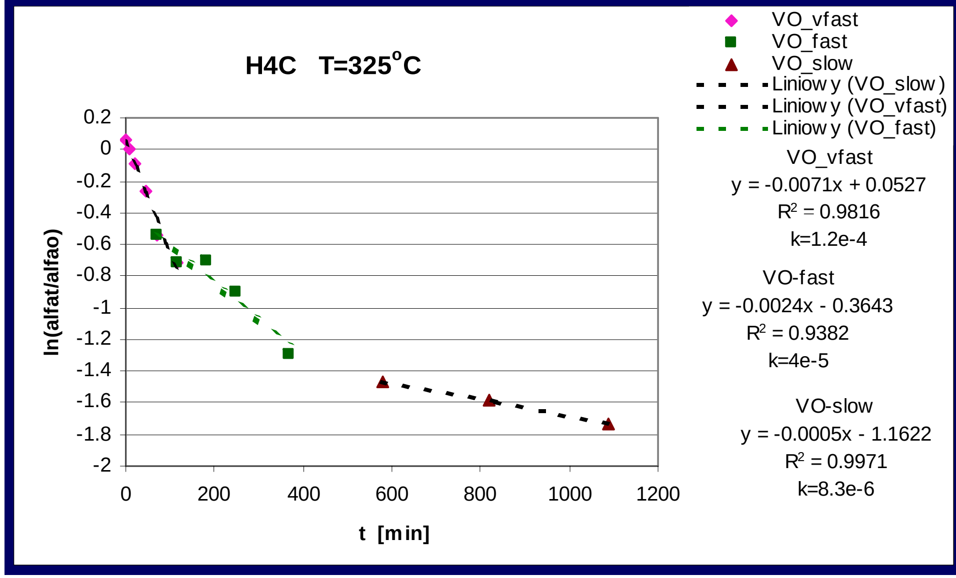
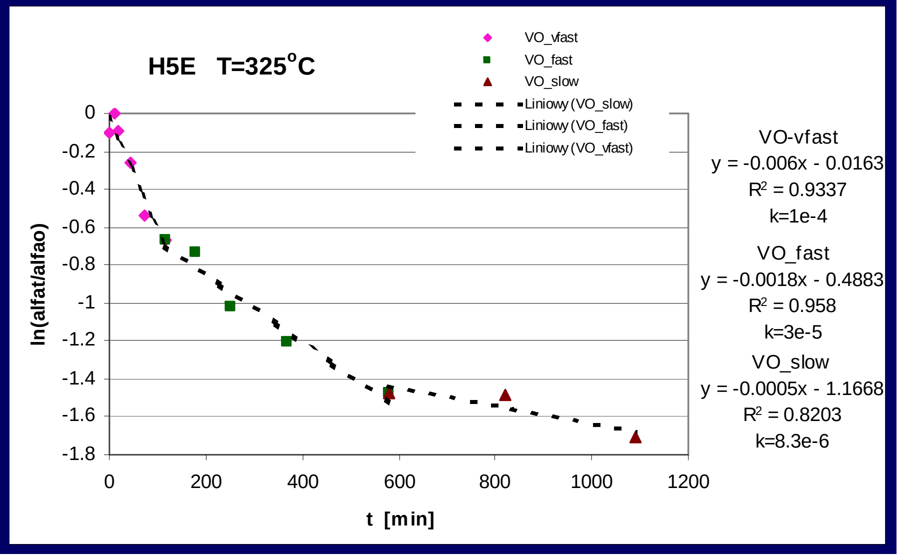
Logarithmic plots of normalised absorption coefficient for VO versus time of annealing at 325°C for the samples with different carbon concentration









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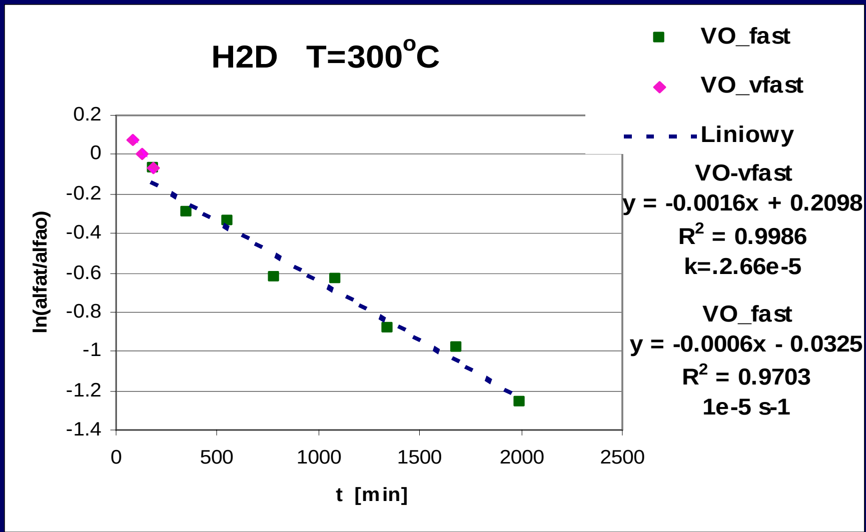
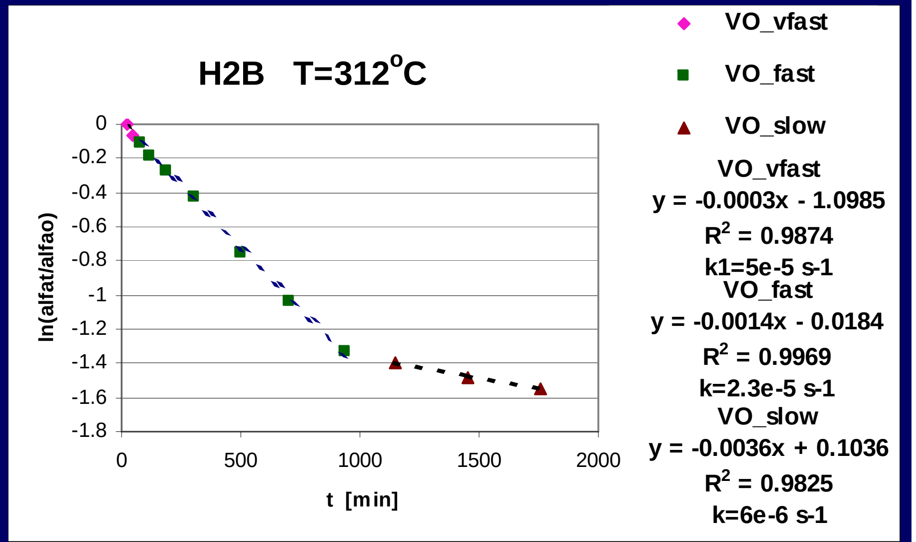
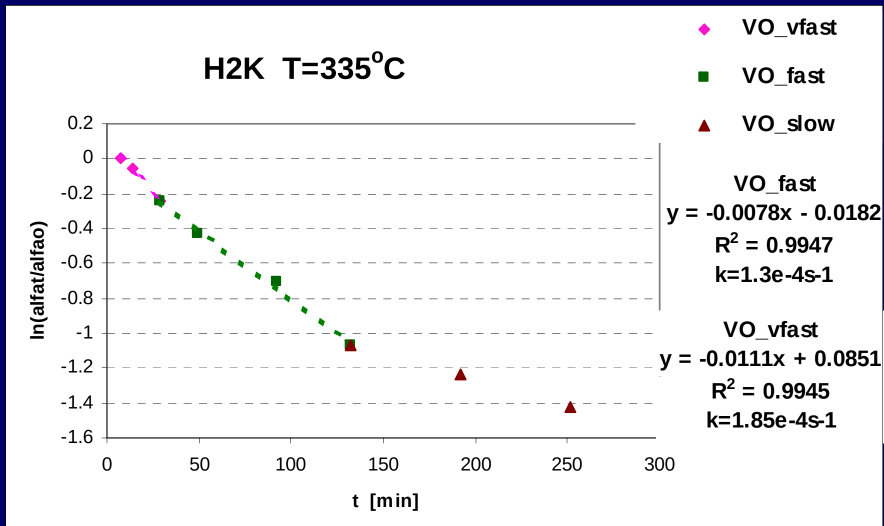
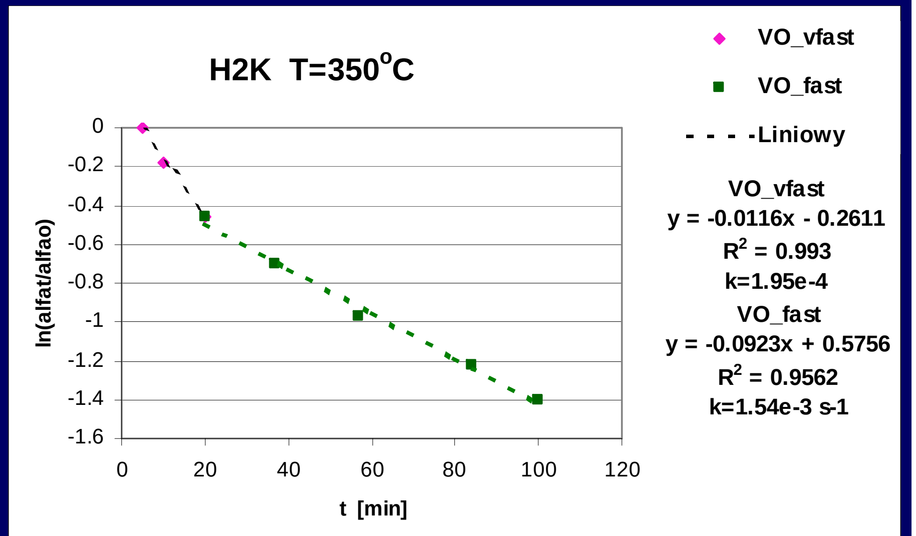
Logarithmic plots of normalised absorption coefficient for VO versus time of annealing for the samples from H2 crystal at different temperature









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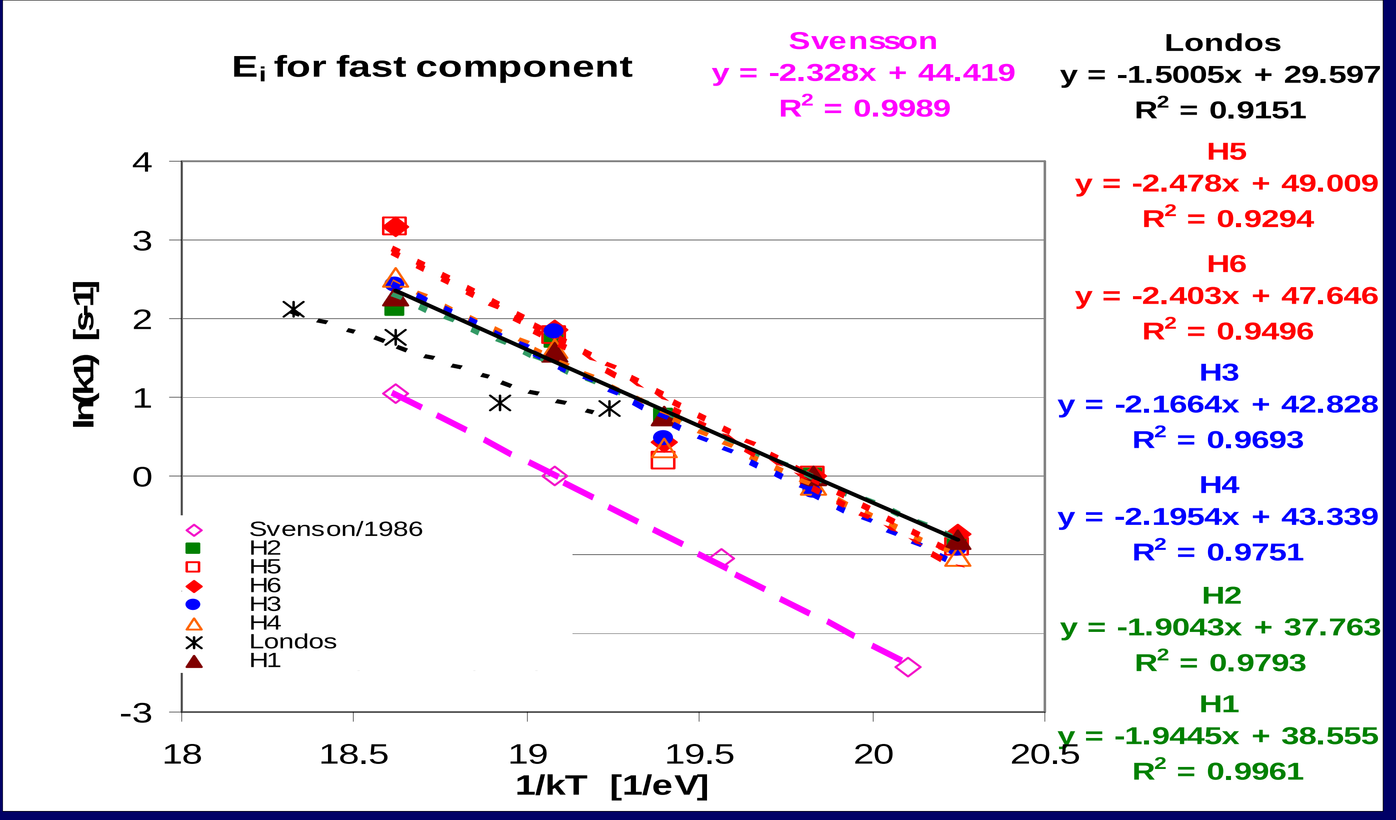
Arrhenius plots for the fast component of the annihilation of VO defects

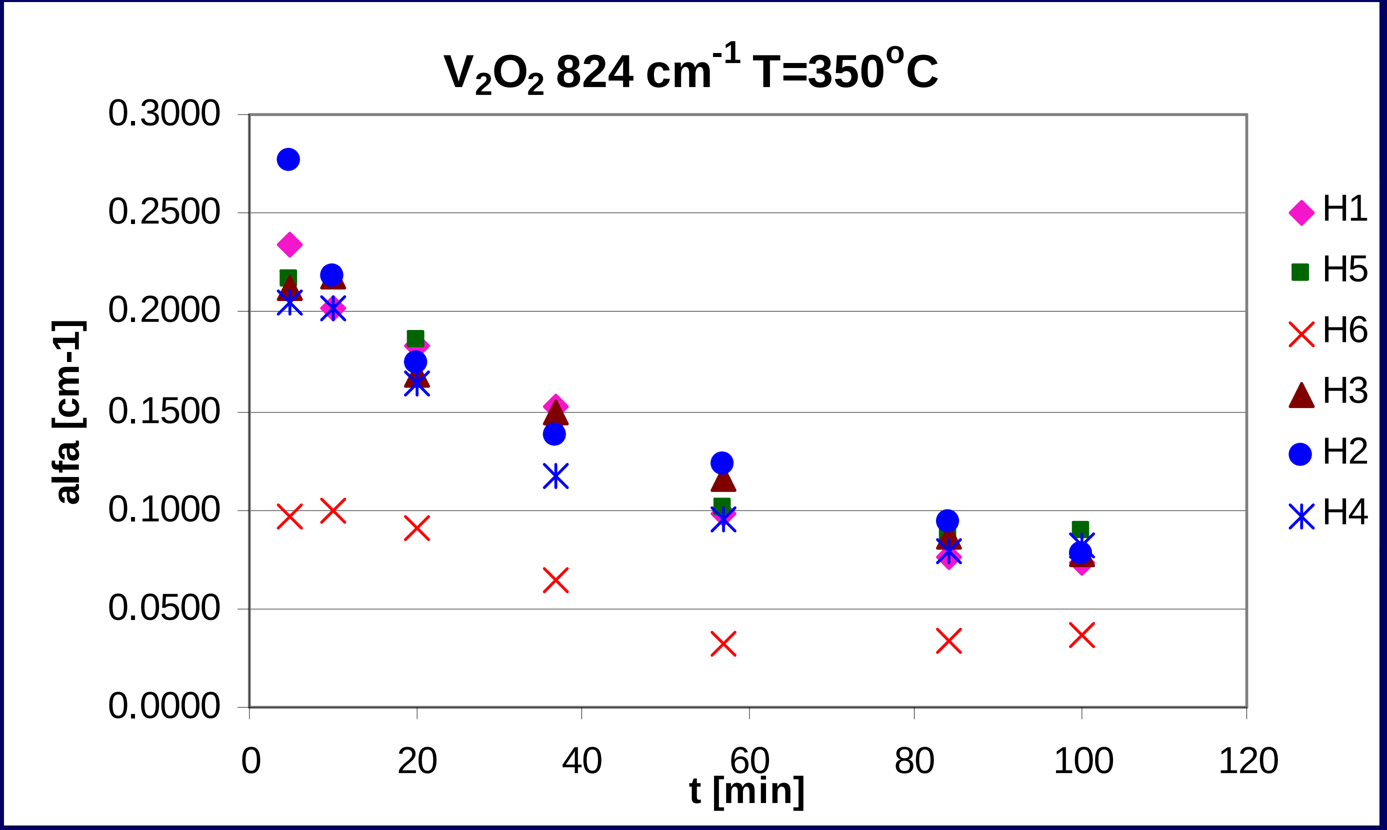
Effect of carbon concentration on the activation energy of the annihilation process of VO complexes



B. Svenson and J. L. Lindström: Phys. Rev. B34, (1986), 870,

C. A. Londos, N. V. Sarlis, L. G. Fytros: J. Appl. Phys. V85, (1999), 8074-78.

The intensity of the absorption band at 824 cm^{-1} related to V_2O_2 defects



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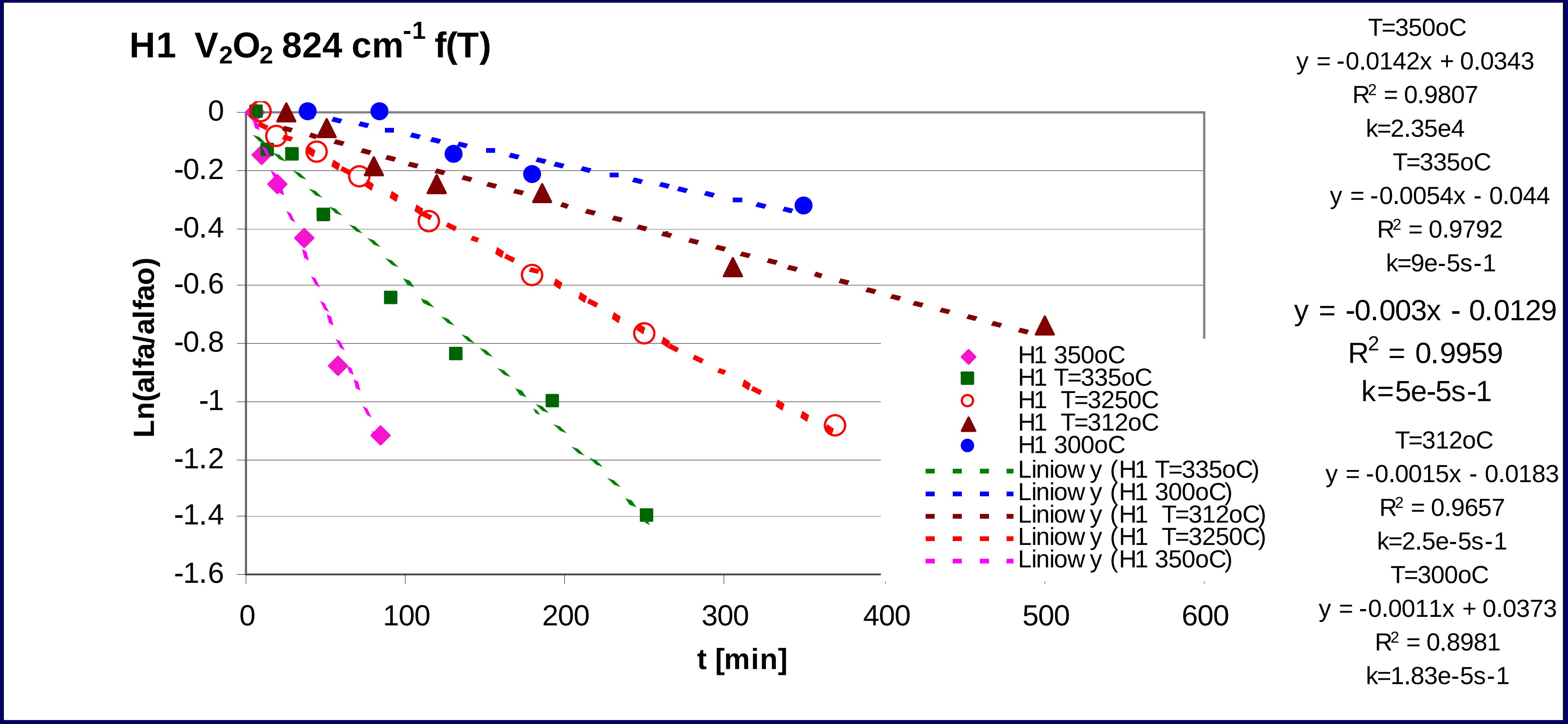
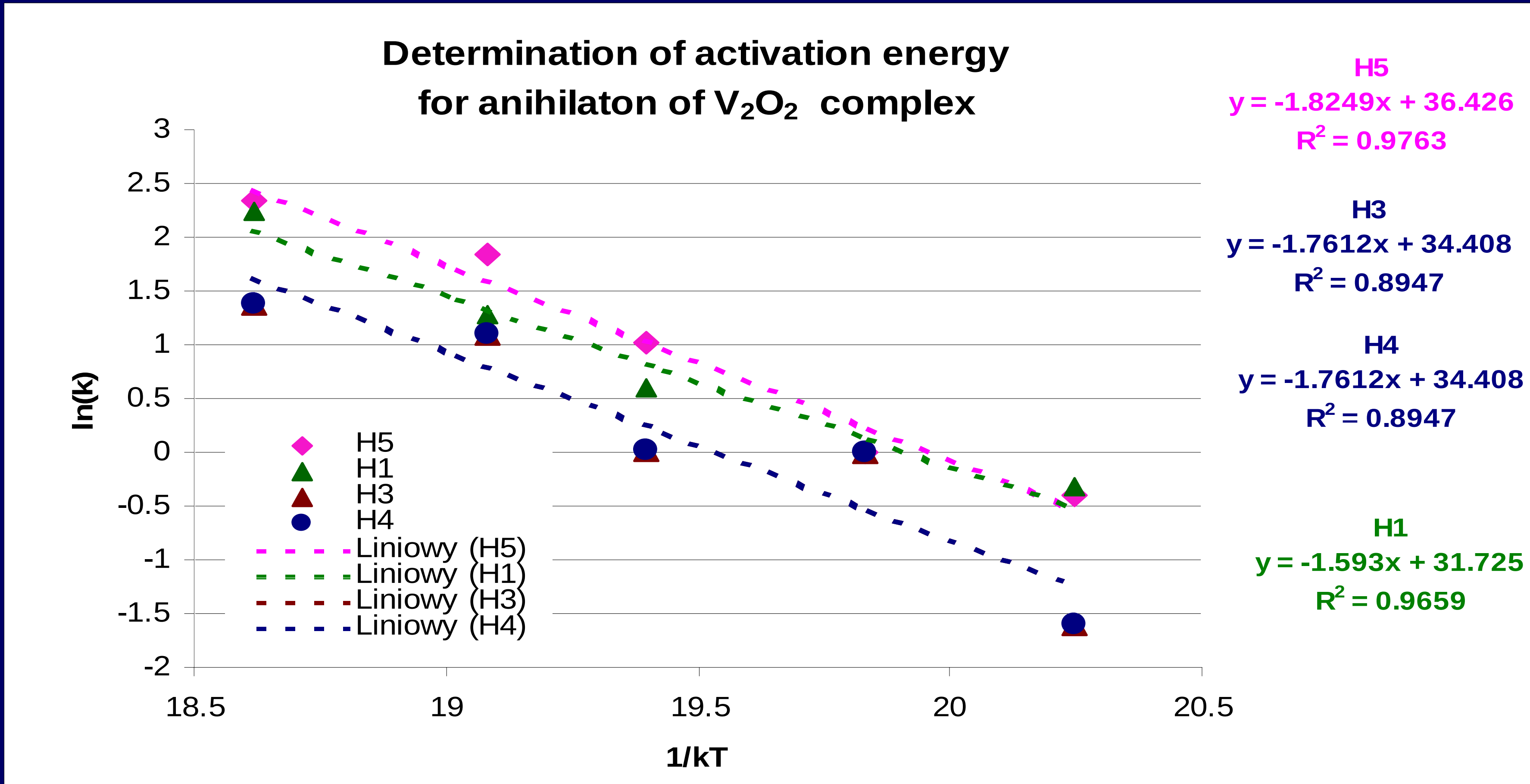
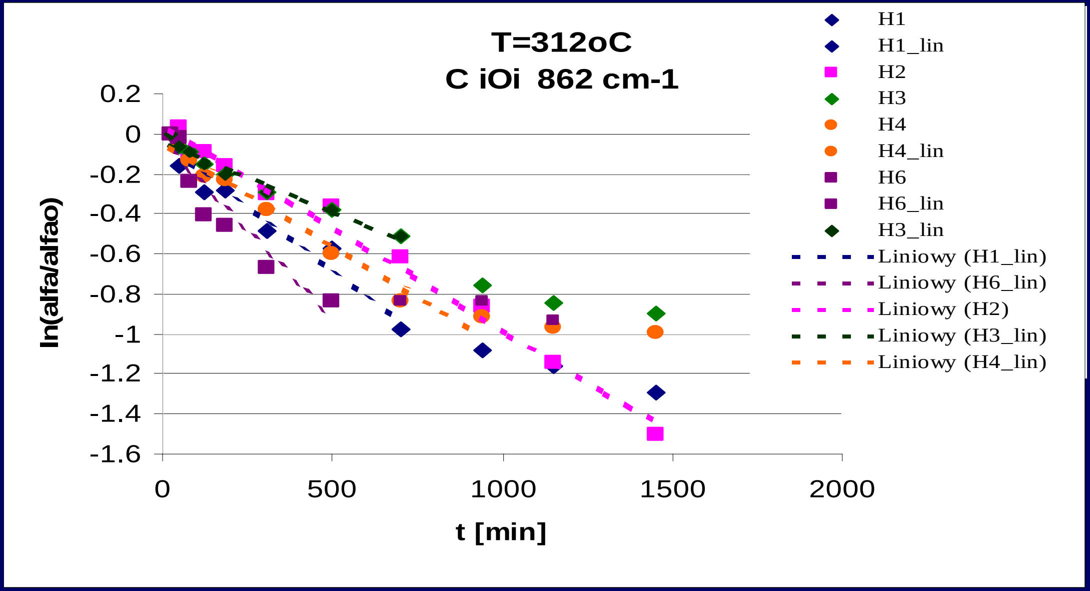
Logarithmic plots of normalised absorption coefficient for V_2O_2 versus time of annealing at various temperatures for the samples from the H1 crystal

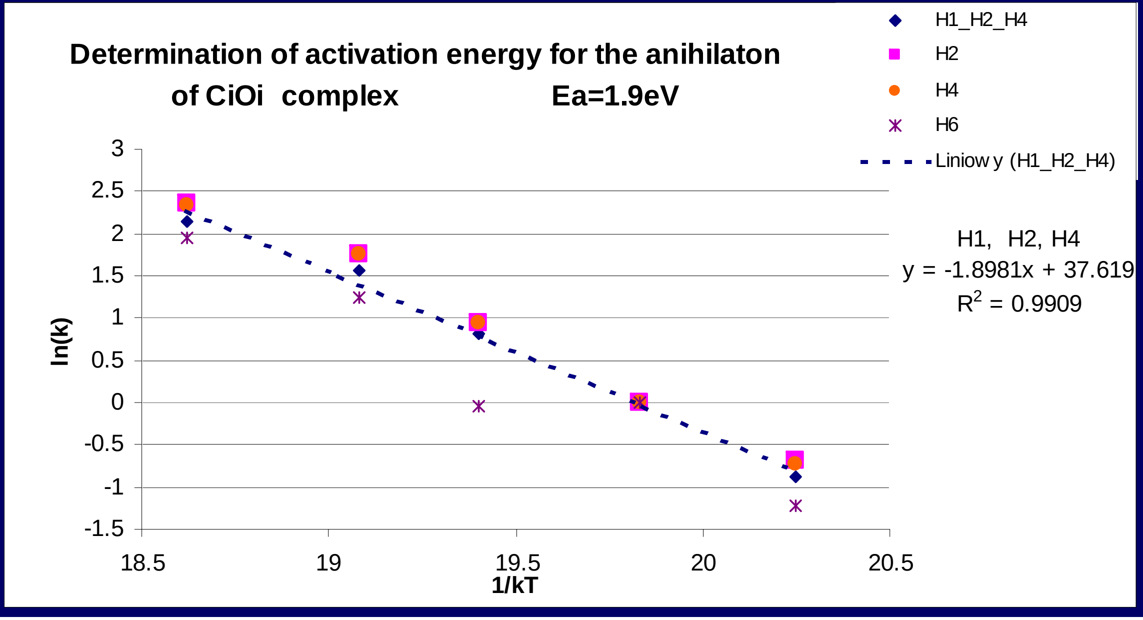


Activation energy for anihilation of V_2O_2 complex



Annihilation of C_iO_i defects





Arrhenius plot

E_a=1.9eV

Multi-reaction model

$k0=4\pi R(Dvo+Do)$	$VO+Oi \Rightarrow VO2$		(1)
$k1=D_d$	$VO \Rightarrow V+Oi$		(2)
$k2=4\pi R(Dvo+Di)$	$VO+I \Rightarrow Oi$		(3)
$k3=4\pi R(Dv+D_{Oi})$	$V+O \Rightarrow VO$		(4)
$k4=4\pi R(Dvo+Dv)$	$VO+V \Rightarrow V_2O$	eliminated	(5)
$k5=4\pi R(Dvo+Dvo)$	$VO+VO \Rightarrow VO_2+V$	eliminated	(6)
$k6=4\pi R(D_{CiOi}+ Dv)$	$CiOi+V \Rightarrow Cs+Oi$		(7)
$k7=D_{CiOidysoc}$	$CiOi \Rightarrow Ci+Oi$		(8)
$k8=4\pi R(D_{vo2}+Do)$	$VO2+O \Rightarrow VO3$		(9)
$k9=4\pi R(D_{Ci}+D_{Oi})$	$Ci+Oi \Rightarrow CiOi$		(10)

Reaction kinetics

d(VO)/dt=-4πR(Dvo+Doi)[VO][Oi]-Dd[VO]-4πR(Dvo+Di)[VO][I]+4πR(Dv+Doi)[V][Oi]- 4πR(Dvo+Dv)[VO][V]-4πR(Dvo]^2

dOi/dt=+4πR(Dvo+Di)[VO][I] Dd[VO]-4πR(Dvo+Doi)[VO][Oi] 4πR(Dv+Doi)[V][Oi]+4πR(DCiOi+Dv)[CiOi][V]

d(VO2))/dt=+4πR(Dvo+Doi)[VO][Oi]+4πR(Dvo]^2-4πR(DCiOi+Di)[CiOi][I]

d(I)/dt=-4πrR(Dvo+Di)[VO][I]-4πR(DCiOi+Di)[CiOi][I]

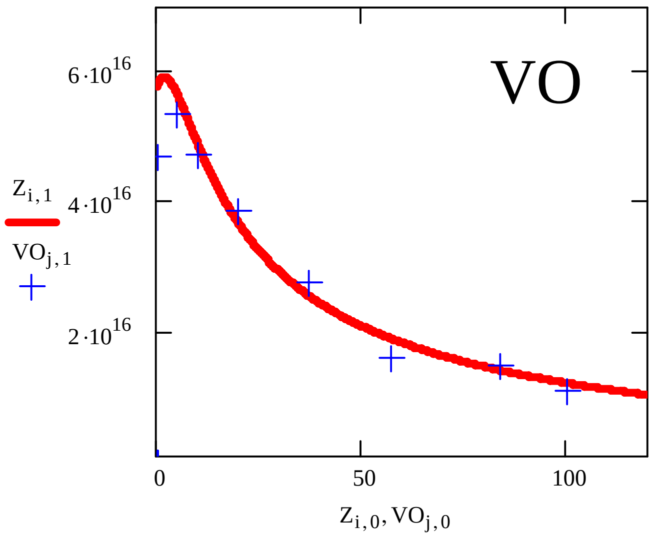
d(V)/dt=+Dd[VO] 4πR(Dv+DOi)[V][Oi]-4πR(Dvo+Dv)[VO][V]+4πR(Dvo]^2-4πR(DCiOi+Dv)[CiOi][V]

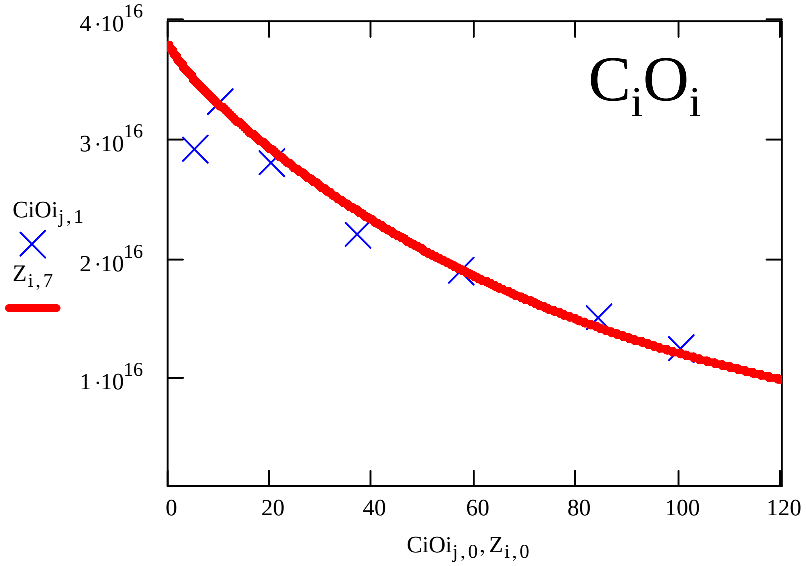
d(V2O)/dt=4πR(Dvo+Dv)[VO][V]

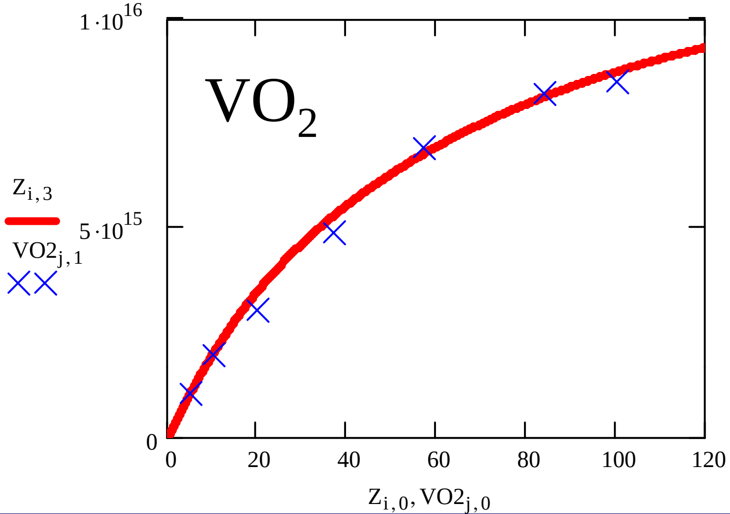
d(CiOi)/dt=-4πR(DCiOi+Dv)[CiOi][V]+DCiOidys*[CiOi]+4πR(DCi+DOi)[Ci][Oi]

d(Ci)/dt=-4πR(DCi+DOi)[Ci][Oi]+DCiOidys*[CiOi]

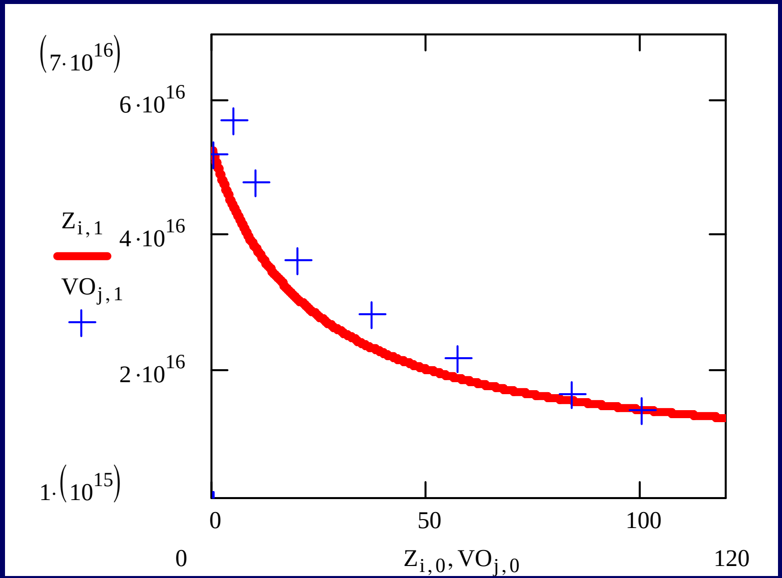
Fitting results



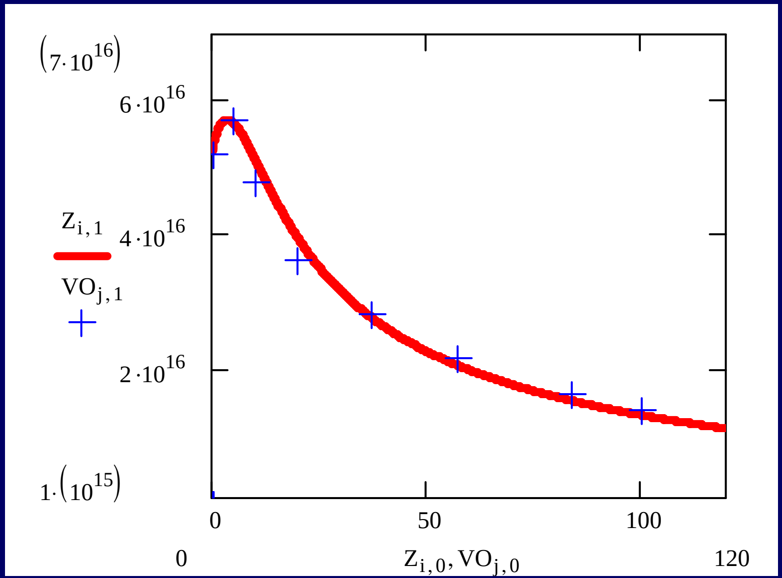




The role of V+O=VO reaction

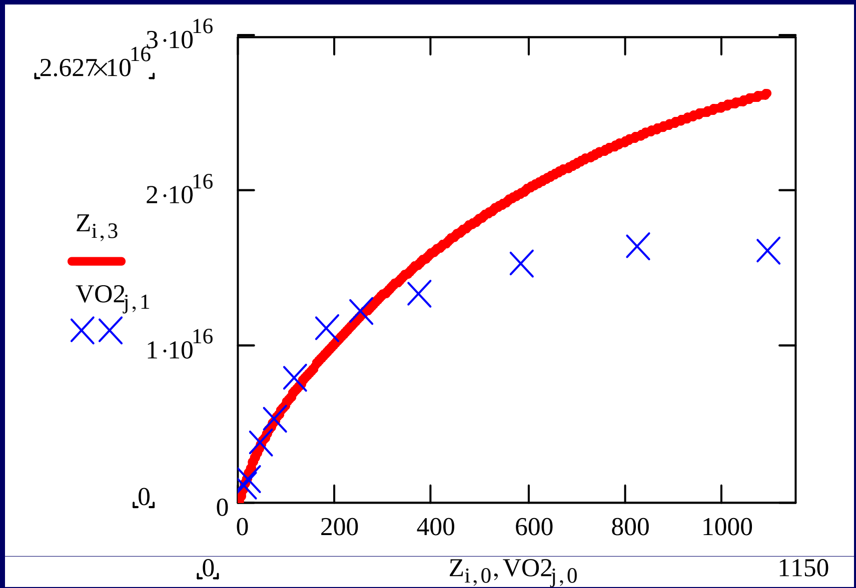


Not considered

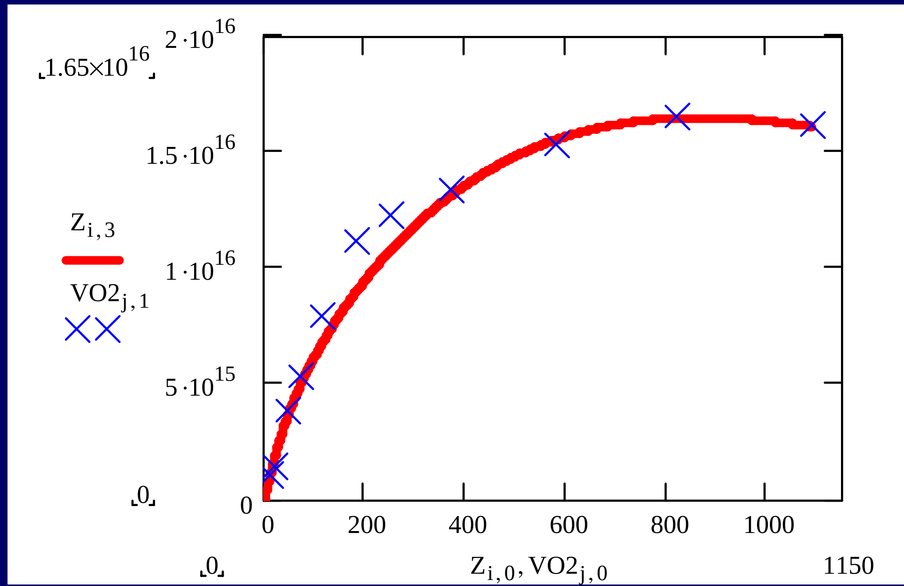


considered

The role of $VO_2+O=VO_3$ reaction

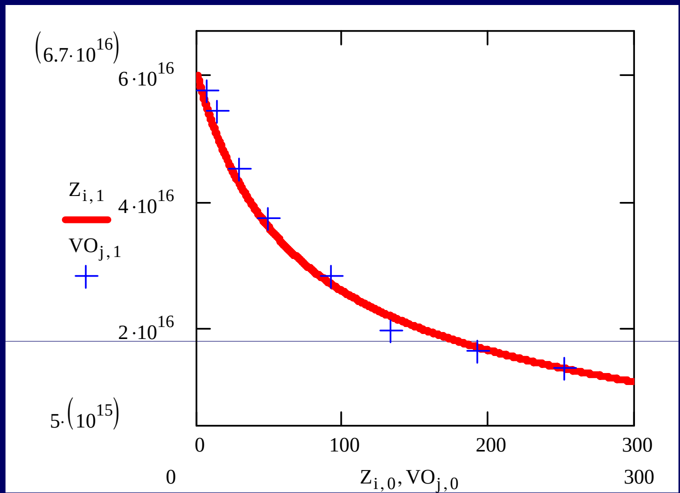


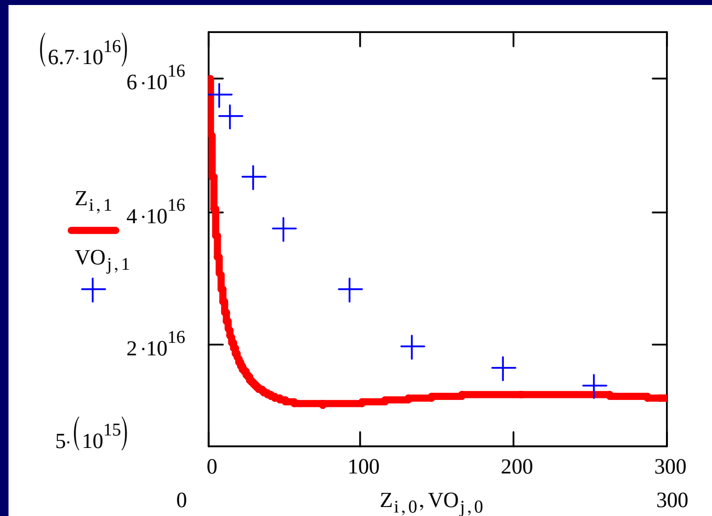
Not considered



considered

Effective diffusion coefficient for I

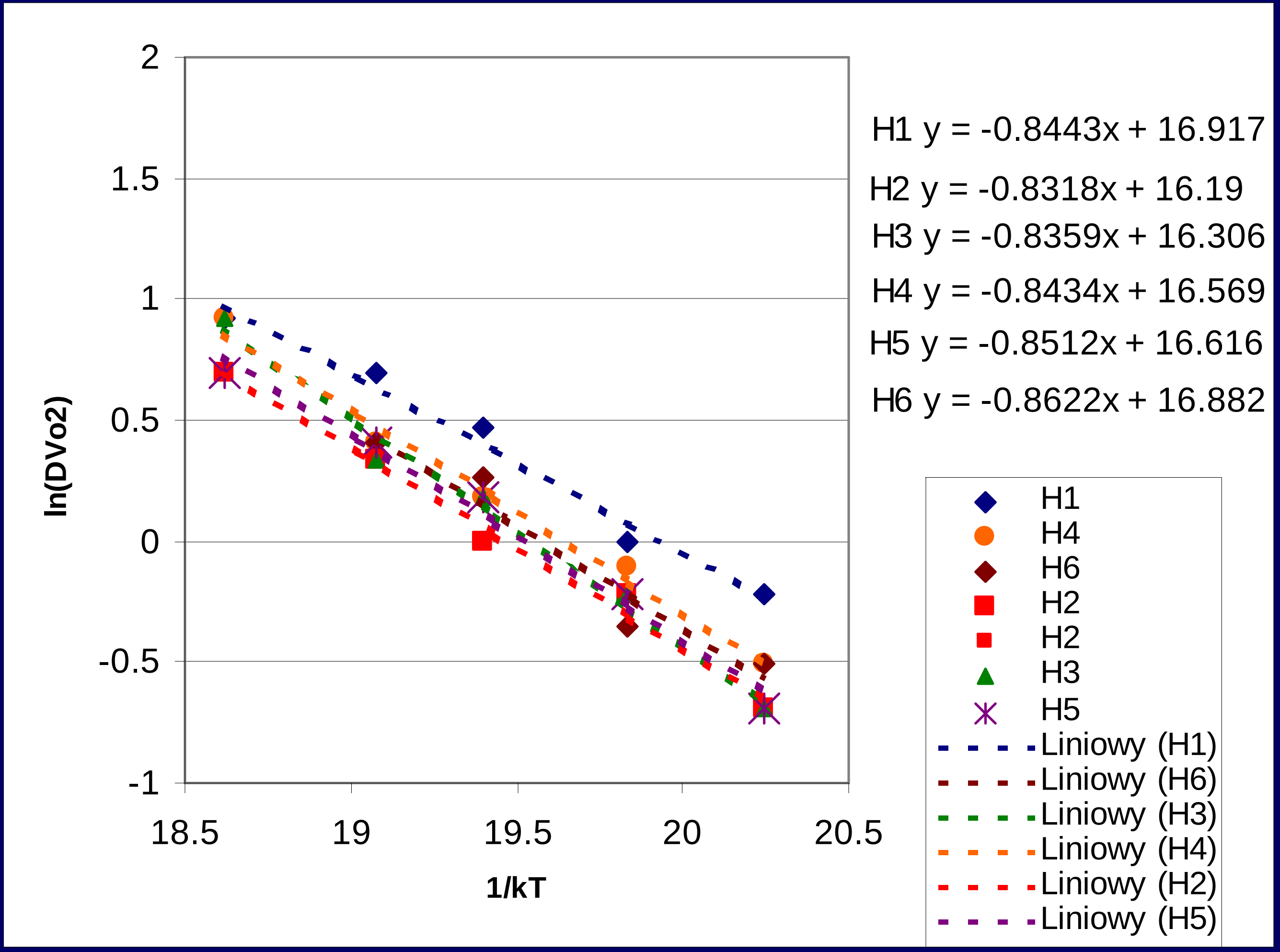




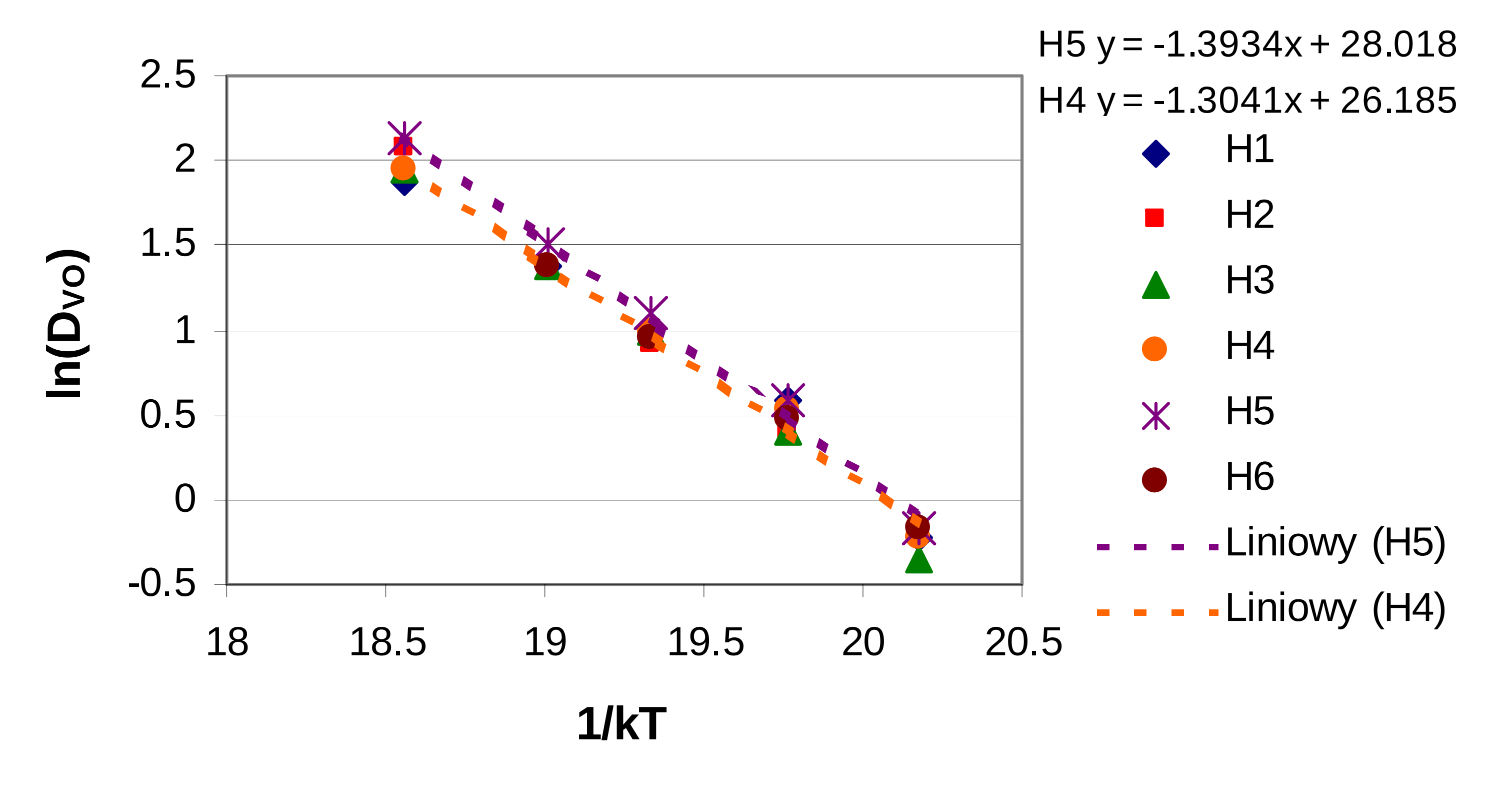
D_I=3.8*10^{-14}cm^2/s

D_I=3.8*10^{-13} cm^2/s

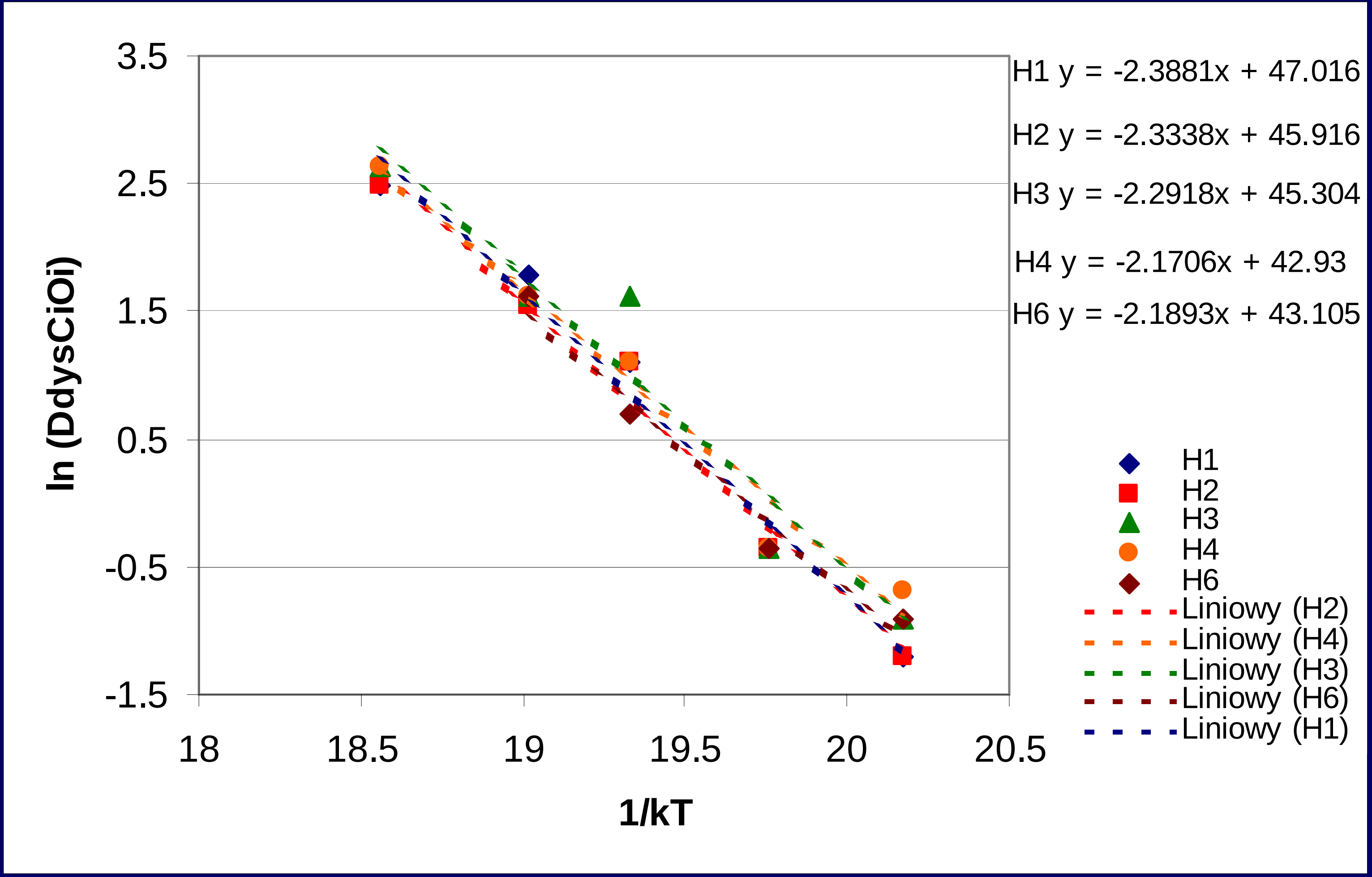
Activation energy for diffusion coefficient D for VO_2 defects



Activation energy for diffusion of VO complex



Activation energy for dissociation of C_iO_i defects



Conclusions (1)

- The kinetic studies of formation and annihilation of complex defects involving oxygen and carbon atoms for the neutron irradiated silicon with enhanced carbon concentration have been performed.

- The concentrations of the defects were calculated from the intensity of the FTIR absorption measurements.

- The temperature dependences of the reaction rate constants have been determined and activation energies for annihilation of V_2O_2 and C_iO_i defects have been found to be 1.7 eV and 1.9 eV, respectively

- An effect of the carbon concentration on the reaction rate constants for the annihilation of VO defect has been observed. The increase of the carbon concentration resulted in decreasing the activation energy of the annihilation process

Conclusions (2)

- A multi-reaction model has been used for the fitting the experimental data. The fitting procedure allowed to determine :

  - the activation energies for diffusion of VO and VO_2 complexes approximately equal to 1.35eV and 0.84 eV, respectively,

  - the activation energy for dissociation of C_iO_i complex approximately equal 2.3 eV.

Acknowledgements

Acknowledgements:

The author thanks dr Vladimir Cindro and dr Michael Moll for neutron irradiations.

Diffiusion coefficient of V and I

According to Sinno D_V, D_I are expressed by the formulas:
$D_V=1*10^{-3}exp(-0.457/kT)$ i $D_I= 0.242exp(-0.937/kT)$

So at T=350oC $D_V=2.035*10^{-7}$ cm^2/s and $D_I=6.53*10^{-9}$ cm^2/s.

T. Sinno, R. A. Brown, W. Von Ammon, E. Dornberg , Appl.Phys.Lett. V70(17) 2250-2252, 1997

Dissociation

Dissociation process

$$-\partial[N]/\partial t = D_{dys} * [N]$$

D_{dys} –rate constant for dissociation

The range of uncertainty for fitting parameters

	at/cm^3	at/cm^3	at/cm^3	at/cm^3	at/cm^3									
	[VO]	[O]	[I]	[V]	[CiOi]	D_{VO}	D_O	D_I	D_V	D_{VO2}	$D_{dysCiOi}$	D_{CiOi}	D_{dysVO}	D_{Ci}
	$*10^{16}$	$*10^{17}$	$*10^{16}$	$*10^{16}$	$*10^{16}$	$*10^{-16}$	$*10^{-22}$	$*10^{-14}$	$*10^{-15}$	$*10^{-16}$	$*10^{-3}$	$*10^{-14}$	$*10^{-4}$	$*10^{-15}$
300oC	5.76	8.77	3.5	2	3.5	0.85	5	0. 3	0.2	0.7	0.5	0.05	**4**	0.01
300oC	5.76	8.77	**3.5**	**1**	3.5	0.85	5	**0. 3**	**0.2**	0.7	0.5	0.05	**0.4**	0.01
300oC	5.76	8.77	**6**	**4.5**	3.5	0.85	5	**0.45**	**0.2**	0.8	0.4	0.1	**0.4**	0.01
312oC	5.76	8.77	7	10	3.8	1.8	5	0.8	0.09	0.9	0.6	0.25	**0.4**	**0.1**
312oC	5.76	8.77	7	10	3.8	1.8	5	0.8	0.12	1	0.6	0.25	**4**	**0.1**
325oC	5.76	8.77	7.5	5.2	3.8	2.7	5	10	15	1.6	3	1.5	**4**	**0.1**
325oC	5.76	8.77	7.5	5.2	3.8	2.7	5	10	15	1.6	3	1.5	**0.4**	**0.1**
312oC	5.56	9.88	**6**	**6.5**	4.5	1.5	5	**0.5**	**0.1**	0.8	0.7	0.1	4	**0.01**
312oC	5.56	9.88	**5**	**4.5**	4.5	1.5	5	**0.7**	**0.2**	0.8	0.8	0.2	4	**0.01**
325oC	5.6	9.88	**8**	**6.5**	4.6	2.5	5	**8**	**10**	1	3	1.5	4	**0.1**
325oC	5.6	9.88	**8.5**	**7.5**	4.6	2.5	5	**8**	**7**	1.1	2.5	1.5	4	**0.1**
325oC	2.2	1.80	**3**	**1.1**	1.1	2.6	5	**20**	**20**	1.3	2	0.7	4	**0.12**
325oC	2.2	1.80	**6.8**	**6**	0.96	3.8	5	**3.5**	**0.7**	1.3	1.9	0.4	4	**-**
335oC	1.7	2.00	**7.2**	**5.9**	0.7	4	5	**45**	**80**	1.5	0.8	1.2	4	**0.1**
335oC	1.7	2.00	**6.9**	**5.8**	0.7	4	5	**45**	**80**	1.5	5	1.2	4	**0.1**

Fitting Parameters

TABLE II

Fitting parameters

Sample	Temperature [°C]	at/cm^3 [VO] *10^{16}	at/cm^3 [O] *10^{17}	at/cm^3 [I] *10^{16}	at/cm^3 [V] *10^{16}	at/cm^3 [CiOi] *10^{16}	cm^2/s D_{VO} *10^{-16}	cm^2/s DO *10^{-22}	cm^2/s D_I *10^{-14}	cm^2/s D_V *10^{-15}	cm^2/s D_{VO2} *10^{-16}	s^{-1} $D_{dysCiOi}$ *10^{-3}	cm^2/s D_{CiOi} *10^{-14}	s^{-1} D_{dysVO} *10^{-4}	cm^2/s D_{Ci} *10^{-15}
H1	300	5.76	8.77	6	5.5	3.5	0.8	5	0.4	0.2	0.8	0.3	0.1	4	0.01
	312	5.76	8.77	7	10	3.8	1.8	5	0.8	0.12	1	0.6	0.25	4	0.1
	325	5.76	8.77	7.5	5.4	3.8	2.7	5	10	8	1.6	3	1.5	4	0.1
	335	5.76	8.77	9.5	6.5	3.8	4	5	11	12	2	5.5	1	4	0.1
	350	5.76	8.77	6	2	3.8	6.5	5	15	25	2.5	12	1.5	4	0.1
H2	300	5.56	9.88	2.4	2	4.5	0.85	5	0.7	0.7	0.5	0.4	0.4	4	0.01
	312	5.56	9.88	6	6.5	4.5	1.5	5	0.5	0.1	0.8	0.7	0.1	4	0.01
	325	5.6	9.88	8	6.5	4.6	2.5	5	8	10	1	3	1.5	4	0.1
	335	5.56	9.88	10	8	4.5	4	5	10	9	1.4	4.5	1.2	4	0.1
	350	5.26	9.88	6	3	4.6	7	5	15	35	2	13	1.0	4	0.1
H3	300	5.6	8.70	5	4.3	3.2	0.7	5	0.7	0.7	0.5	0.4	0.6	4	0.01
	312	5.8	8.70	6	4.5	1.5	1.5	5	0.5	0.1	0.8	0.7	0.1	4	0.02
	325	5.37	8.70	7.3	5	1.8	2.7	5	10	10	1.2	5	1.5	4	0.1
	335	5.37	8.70	10	8	2.2	4	5	10	9	1.4	4.5	1.2	4	0.1
	350	5.4	8.70	6	2.3	2	7	5	12	50	2.5	14	1.5	4	0.1
H4	300	5.4	9.00	5	4.8	3.01	0.8	5	0.7	0.4	0.6	0.5	0.2	4	0.01
	312	5.4	9.02	6	4.5	3	1.7	5	0.4	0.1	0.9	1.1	0.1	4	0.08
	325	5.4	9.02	7.5	5.8	3.3	2.7	5	12	20	1.4	3	0.7	4	0.12
	335	5.8	9.02	6	3.3	3	4	5	12	15	1.5	5	1.5	4	0.1
	350	5.4	9.02	6	2	2.7	8	5	12	50	2.5	14	1.5	4	0.1
H5	300	5.5	11.00	2.2	2	<1	0.85	5	0.9	0.4	0.5	-	-	4	-
	312	5.1	11.00	4	5	<1	1.7	5	0.7	0.1	0.6	-	-	4	-
	325	5.6	11.00	6.5	5.5	<1	3	5	12;18	15-20	1.2	-	-	4	
	335	5.3	11.00	6	4.3	<1	5	5	12	15	2.5	-	-	4	-
	350	5.38	11.00	7	4.5	<1	8.5	5	15	20	2	-	-	4	-
H6	300	1.9	2.00	3	1.8	0.9	0.85	5	0.7	0.2	0.6	0.4	0.2	4	0.01
	312	2	2.10	6	6.3	0.8	1.6	5	1.3	0.1	0.7	0.8	0.4	4	0.1
	325	2.2	1.80	3	1.1	1.1	2.6	5	20	20	1.3	2	0.7	4	0.12

SET OF EQUATIONS TO BE SOLVED

$$
d(t,N) := \begin{bmatrix}
\left(-k_0 \cdot N_0 \cdot N_1 - k_1 \cdot N_0 - k_2 \cdot N_0 \cdot N_3 + k_3 \cdot N_1 \ N_4\right) \\
-k_0 \cdot N_0 \cdot N_1 + k_1 \cdot N_0 + k_2 \cdot N_0 \cdot N_3 - k_3 \cdot N_4 \cdot N_1 + k_6 \cdot N_6 \cdot N_4 + k_7 \cdot N_6 - k_8 \cdot N_2 \cdot N_1 \\
k_0 \cdot N_1 \cdot N_0 - k_8 \cdot N_2 \cdot N_1 \\
-\left(k_2 \cdot N_0 \cdot N_3\right) - \left(k_8 \cdot N_3\right) \\
k_1 \ N_0 - k_3 \cdot N_4 \cdot N_1 - k_6 \cdot N_6 \cdot N_4 \\
k_4 \cdot N_0 \cdot N_4 \\
-k_6 \cdot N_6 \cdot N_4 - k_7 \cdot N_6 + k_9 \cdot N_7 \cdot N_1 \\
k_7 \cdot N_6 - k_9 \cdot N_7 \cdot N_1
\end{bmatrix}
$$

$$
N := \begin{pmatrix}
5.76 \cdot 10^{16} \\
8.77 \cdot 10^{17} \\
0 \\
6 \cdot 10^{16} \\
2 \cdot 10^{16} \\
0 \\
3.8 \cdot 10^{16} \\
1 \cdot 10^{16}
\end{pmatrix}
$$

Deconvolution results

				TABLE II T=300°C										
Sample	thickness	Abs. Line	as irradiated	TX1 300oC/40' abs.coeff. [cm-1]	TX2 300oC/45' abs. coff [cm-1]	TX3 300oC/45' abs.coeff [cm-1]	TX4 300oC/45' abs.coeff. [cm-1]	TX5 300oC/170' abs.coeff. [cm-1]	TX6 300oC/200' abs.coeff. [cm-1]	TX7 300oC/235' abs.coeff. [cm-1]	TX8 300oC/300' abs.coeff. [cm-1]	TX9 300oC/250' abs.coeff. [cm-1]	TX10 300oC/345' abs.coeff [cm-1]	TX11 300oC/315' abs.coeff. [cm-1]
Total time [min]			0	40	85	130	180	350	550	785	1085	1335	1680	1995
1/T														
H1K	0.197	V_2O_2_824		0.2768	0.2929	0.2538	0.2366	0.2119	0.2000	0.1815	0.1300	0.1648	0.1368	0.1532
od TX2	0.186	VO_830	0.5762	0.5560	0.5482	0.5035	0.4822	0.4227	0.3414	0.3118	0.2263	0.2114	0.1878	0.1467
		836		0.1295	0.1149	0.1398	0.1413	0.1375	0.1511	0.1367	0.1540	0.1529	0.1593	0.1902
		V_2O_839		0.1654	0.1774	0.1613	0.1647	0.1766	0.1839	0.2021	0.1909	0.2215	0.2153	0.2117
H2D	0.2	V_2O_2_824		0.2672	0.2889	0.2470	0.2510	0.1823	0.1929	0.1680	0.1416	0.1540	0.1211	0.1202
od TX2	0.185	VO_830	0.5556	0.5315	0.5747	0.5329	0.4950	0.3974	0.3805	0.2842	0.2840	0.2198	0.1993	0.1508
		836		0.1236	0.1336	0.1278	0.1336	0.1298	0.1358	0.1824	0.1172	0.1535	0.1574	0.1327
		V_2O_839		0.1515	0.1639	0.1638	0.1597	0.1591	0.1840	0.1996	0.2038	0.2160	0.2175	0.1903
H3H	0.202	V_2O_2_824		0.2315	0.2483	0.2187	0.2230	0.2002	0.1704	0.1448	0.1244	0.1178	0.1068	0.0912
od TX2	0.191	VO_830	0.5369	0.5233	0.5012	0.4764	0.4411	0.3885	0.3304	0.2832	0.2373	0.1911	0.1672	0.1673
		836		0.1121	0.1098	0.1227	0.1174	0.1165	0.1313	0.1154	0.1420	0.1514	0.1430	0.1444
		V_2O_839		0.1476	0.1513	0.1498	0.1524	0.1543	0.1647	0.1737	0.1888	0.1895	0.2220	0.2088
H4I	0.202	V_2O_2_824		0.2274	0.2409	0.2282	0.2194	0.1957	0.1710	0.1554	0.1232	0.1256	0.1152	0.1389
od TX2	0.194	VO_830	0.5380	0.4967	0.4942	0.4815	0.4506	0.4046	0.3579	0.2906	0.2566	0.2319	0.1982	0.1553
		836		0.1386	0.1072	0.1211	0.1150	0.1310	0.1319	0.1365	0.1465	0.1388	0.1399	0.1729
		V_2O_839		0.1425	0.1381	0.1484	0.1464	0.1526	0.1711	0.1858	0.2058	0.1957	0.2066	0.2101
H5A	0.215	V_2O_2_824		0.2394	0.2244	0.2206	0.2075	0.1735	0.1569	0.1423	0.1274	0.1058	0.1120	0.1209
od TX2	0.205	VO_830	0.5087	0.5340	0.5083	0.4818	0.4761	0.3980	0.3764	0.3106	0.2523	0.2215	0.1954	0.1582
		836		0.1201	0.1230	0.4818	0.1053	0.1370	0.1161	0.1243	0.1430	0.1661	0.1350	0.1620
		V_2O_839		0.1373	0.1491	0.1490	0.1437	0.1555	0.1653	0.1842	0.1960	0.2132	0.2131	0.1991
H6F	0.2	V_2O_2_824		0.1101	0.1184	0.1056	0.0951	0.0775	0.0721	0.0702	0.0466	0.0508	0.0415	0.0389
od TX2	0.193	VO_830	0.1808	0.1860	0.1860	0.1498	0.1455	0.1304	0.1008	0.0917	0.0652	0.0560	0.0454	0.0260
		836		0.0727	0.0808	0.0958	0.0899	0.0904	0.0957	0.0941	0.0788	0.0828	0.0849	0.0655
		V_2O_839		0.0827	0.0930	0.0883	0.0896	0.0917	0.0896	0.1014	0.0774	0.0853	0.0872	0.0822