

Design of a new generation of 12% chromium steels

KME - 710

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Cooperation partners



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	Fang Liu	Chalmers
<i>Reference group:</i>	Bo Jönsson	Sandvik Heating Technology AB, Chalmers

Outline

- **Alloy design concept**
- **Nb vs. Ta**
- **Pathways for Z-phase formation**

Better 9–12% Cr steels

Current status



600°C

9% Cr

Creep

Corrosion

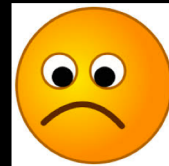


650°C

9% Cr

Creep

Corrosion



Aim



650°C

12% Cr

Creep

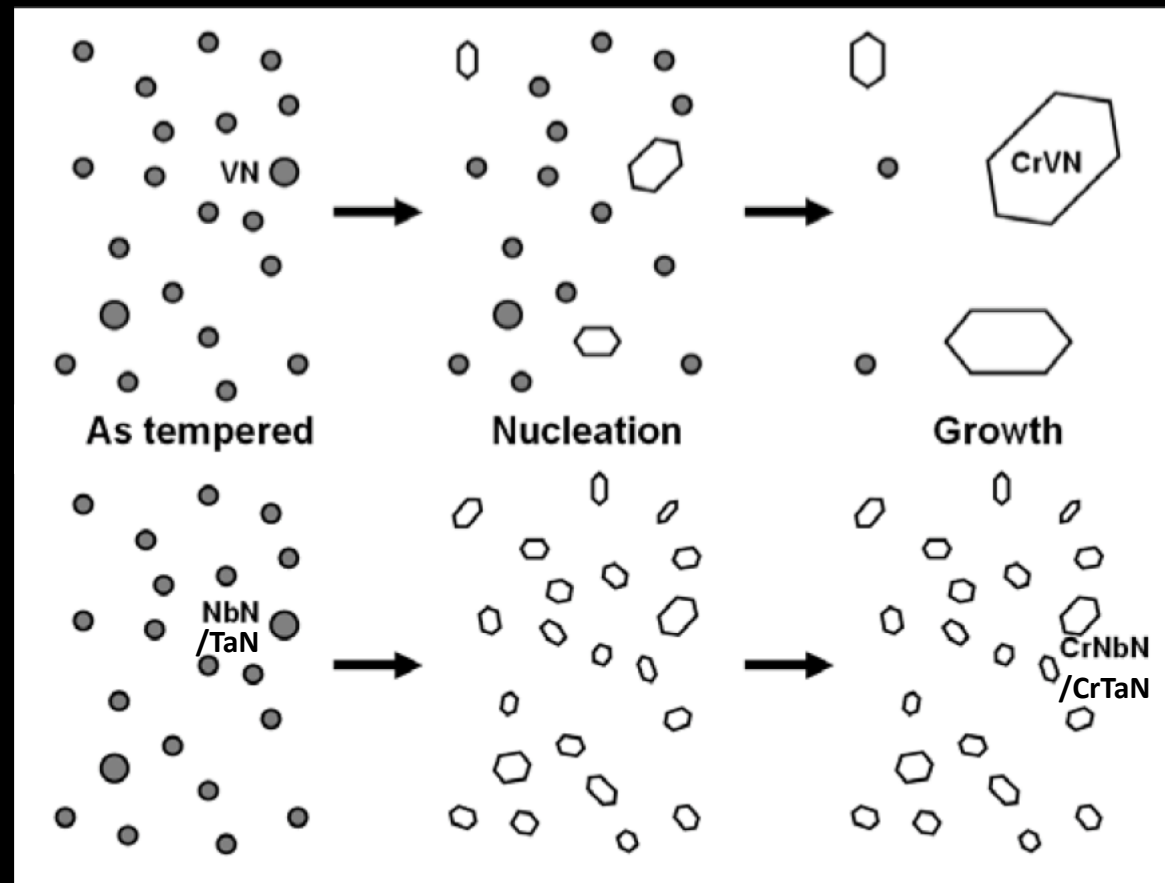
Corrosion



New alloy design concept

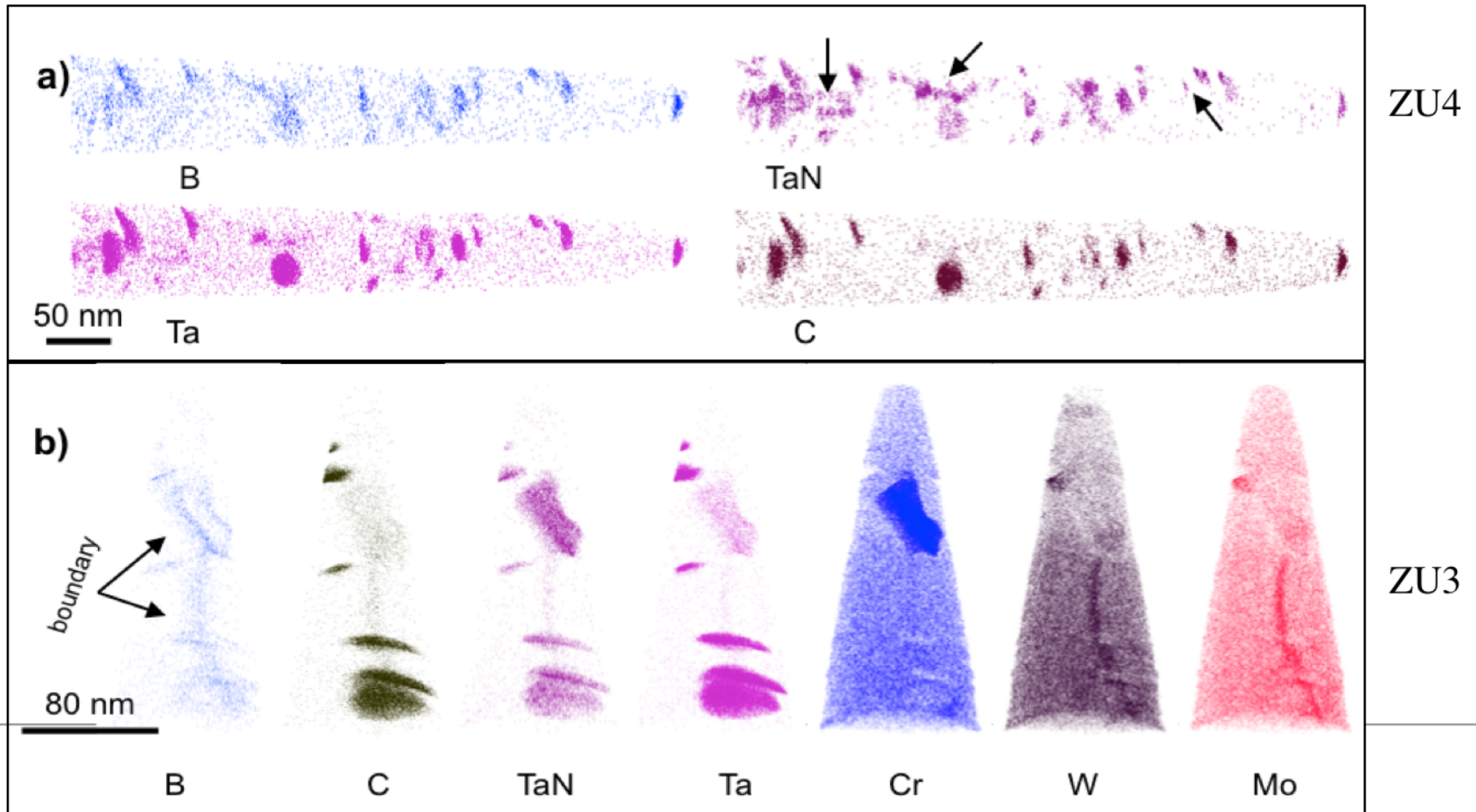
Conventional 12% Cr steels

New generation of 12% Cr steels



*Danielsen and Hald.
VGB power Tech. 5/2009*

Effects of carbon concentration – precipitates Ta(C,N)



Z-phase

CrMN

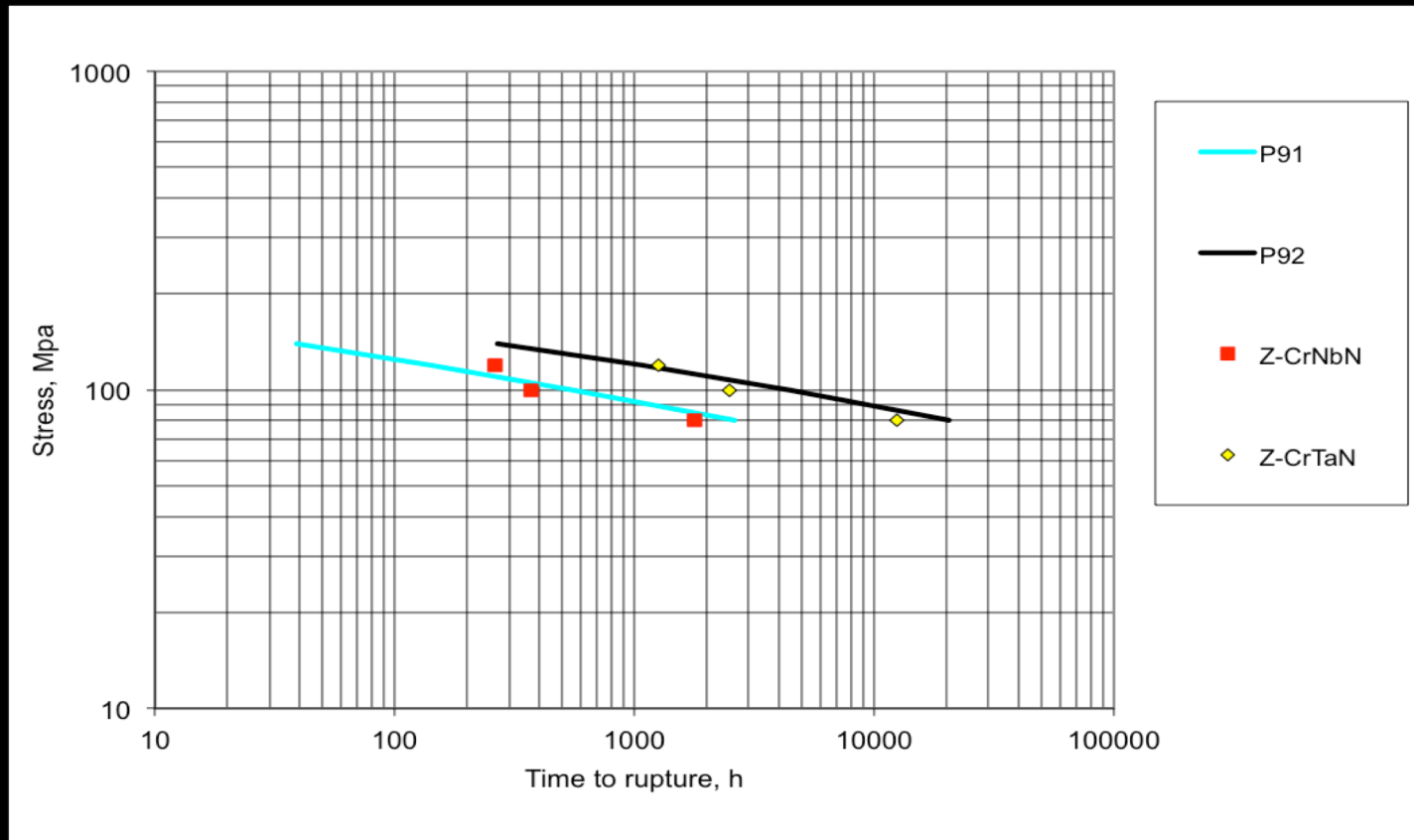
Ta vs Nb

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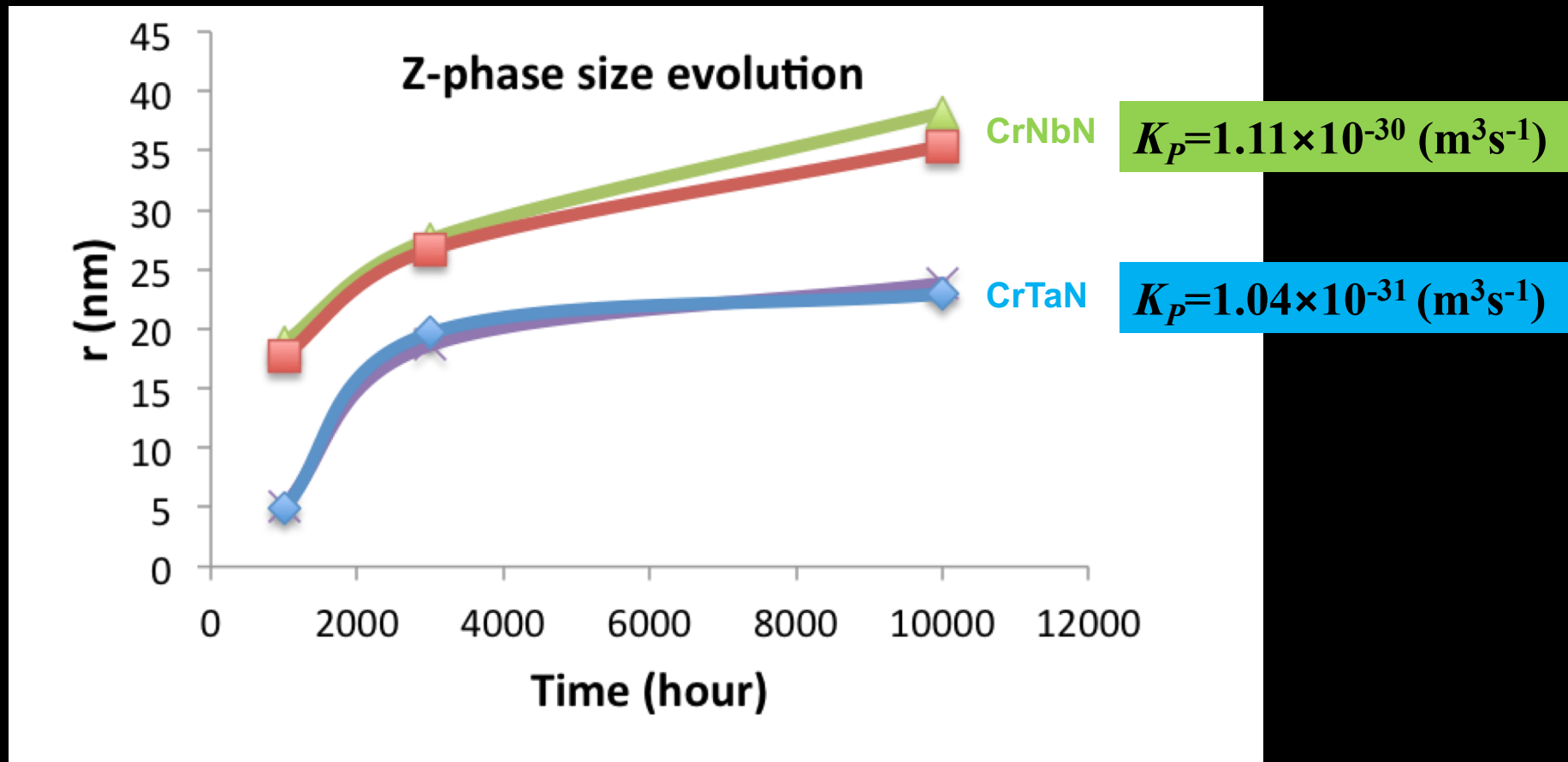
Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period 1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57-71	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89-103	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

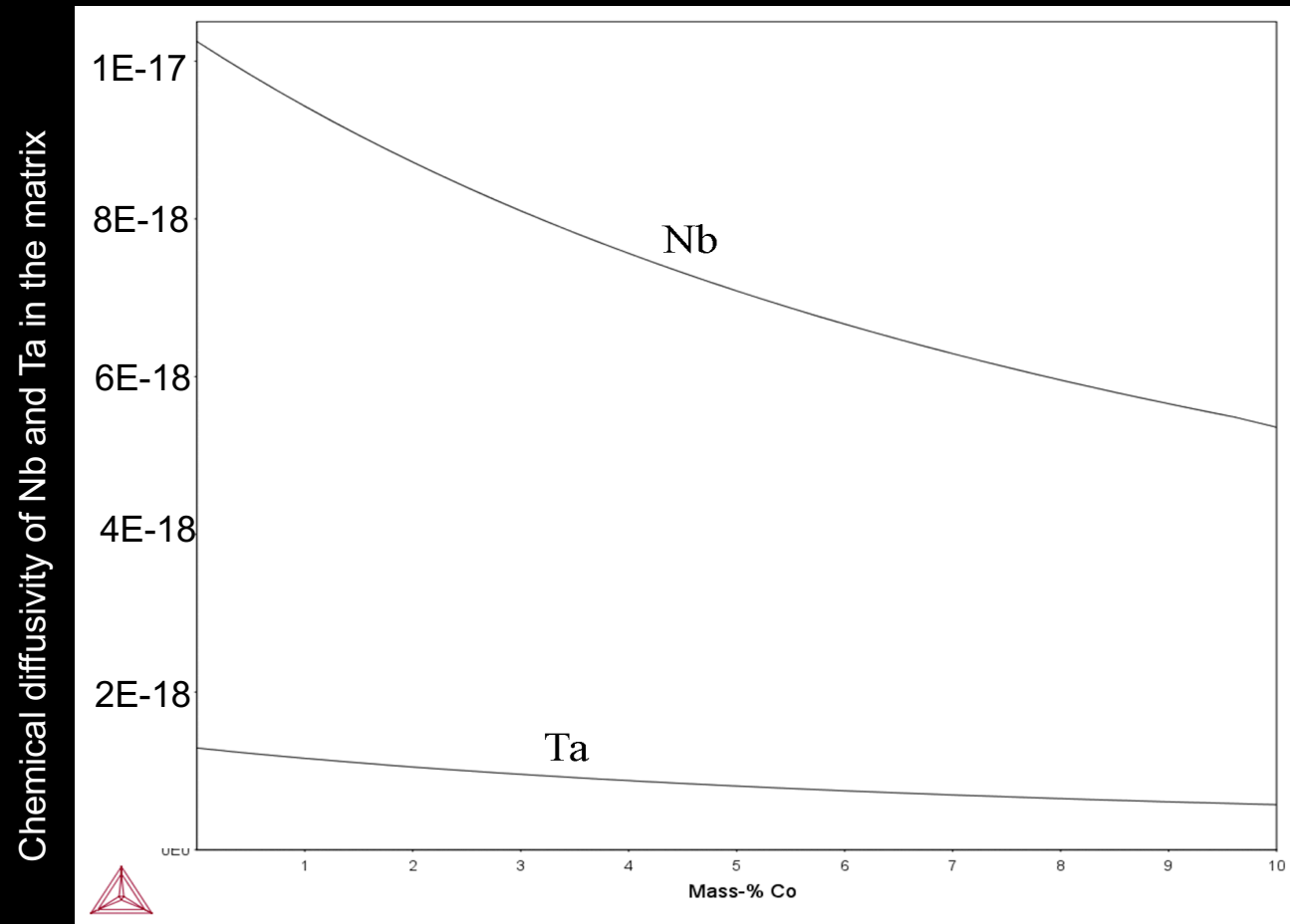
Creep: Ta-containing steel stronger than Nb-containing



Coarsening rate – CrTaN and CrNbN

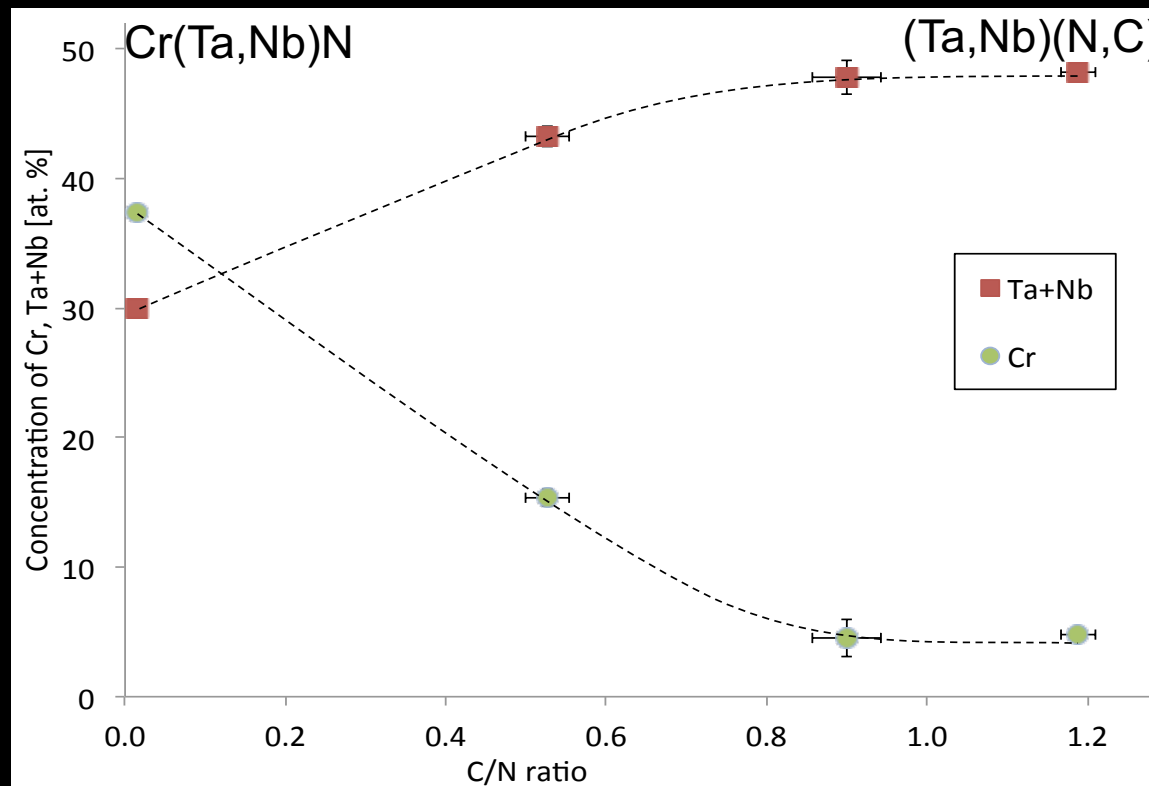


Diffusivity of Nb vs Ta



Pathways of Z-phase formation

Cr Ta N C



Cr

Ta

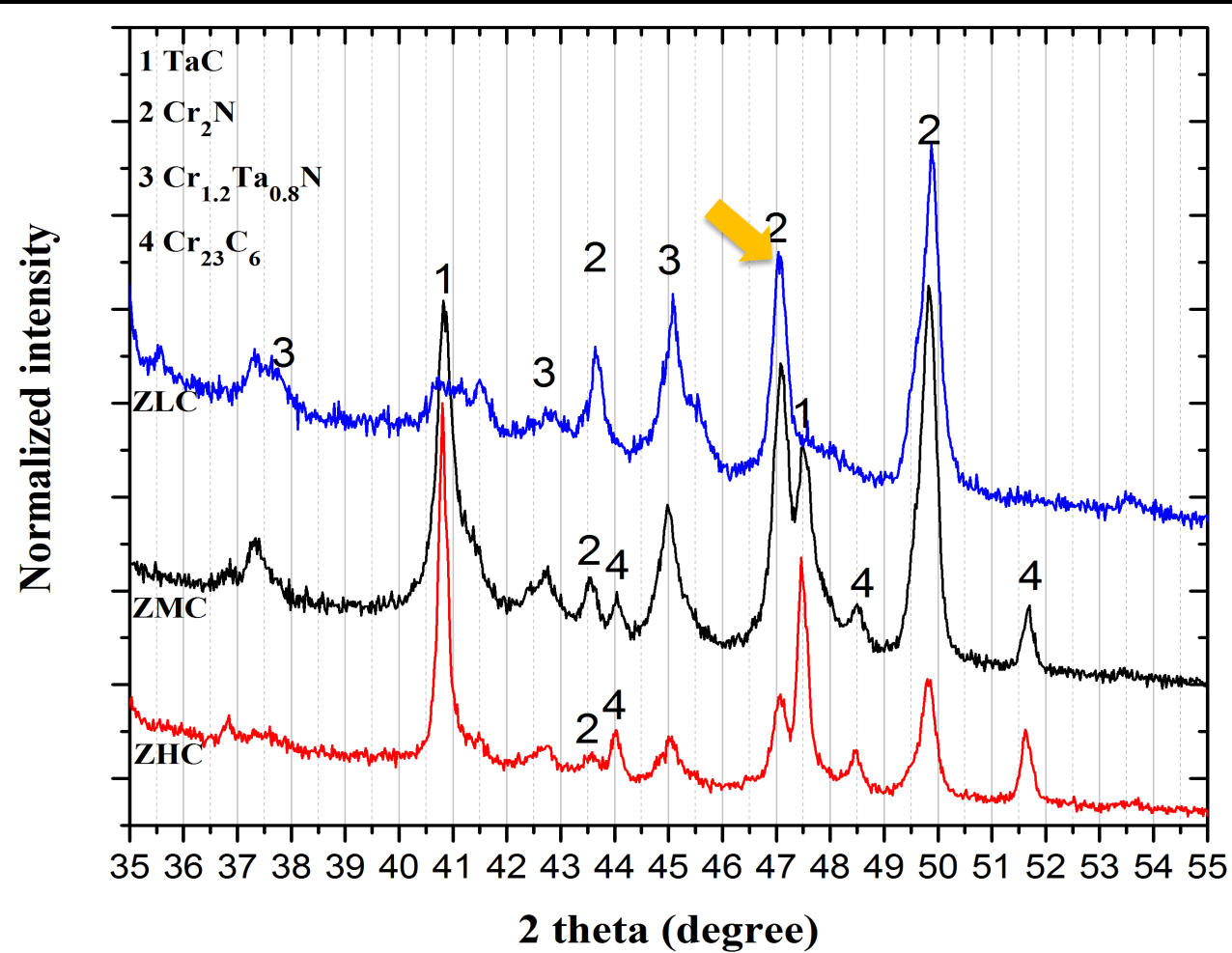
N

C

Cr_2N

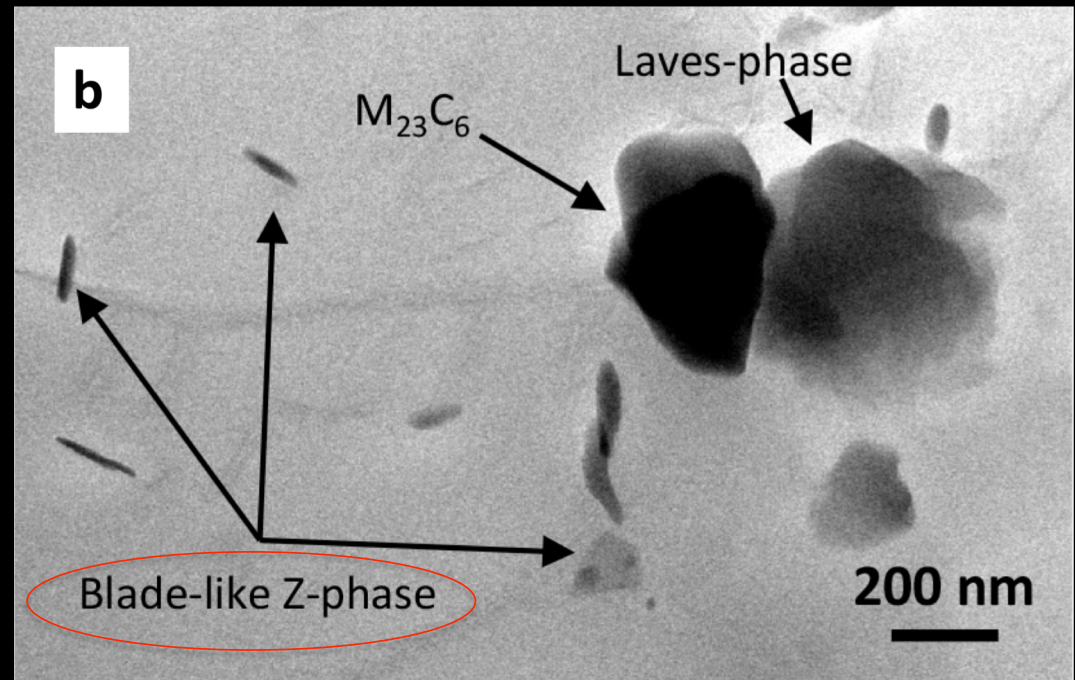
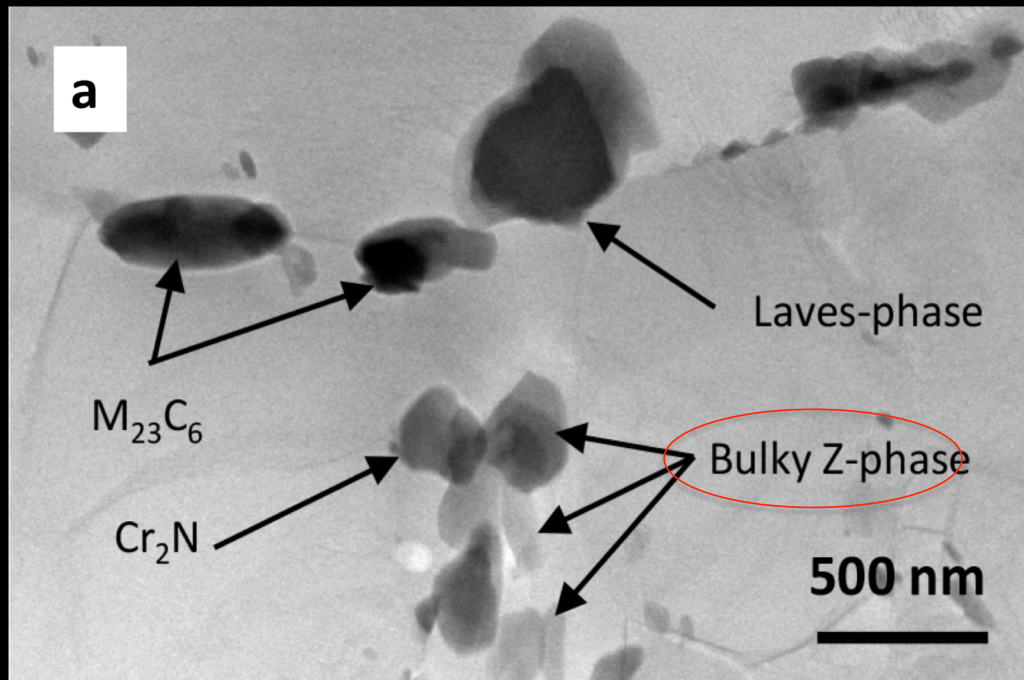


CrTaN



ZLC – C 0.015 wt.%
 ZMC – C 0.028 wt.%
 ZHC – C 0.050 wt.%

Z-phase formation from different pathways



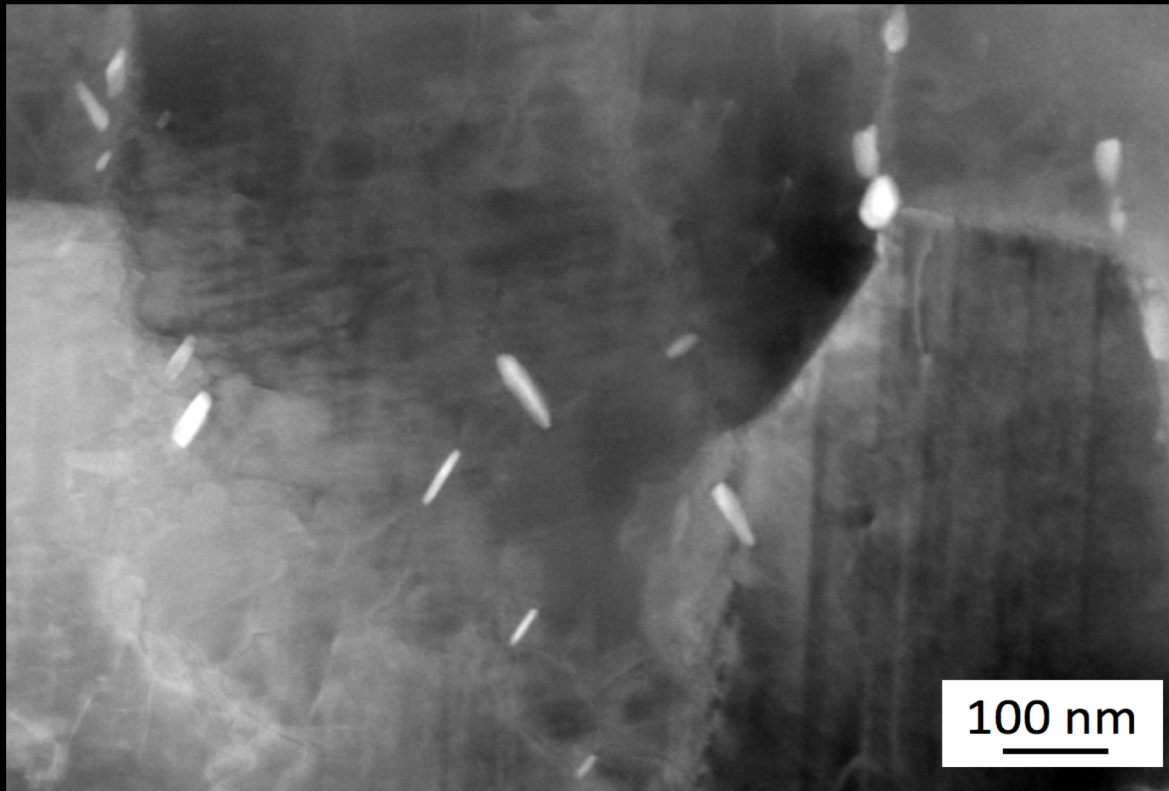
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Cr

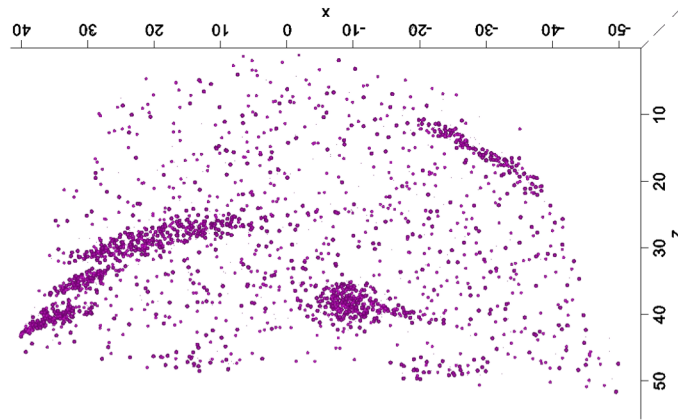
Ta

N

C



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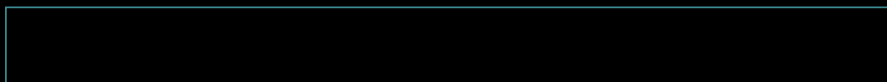
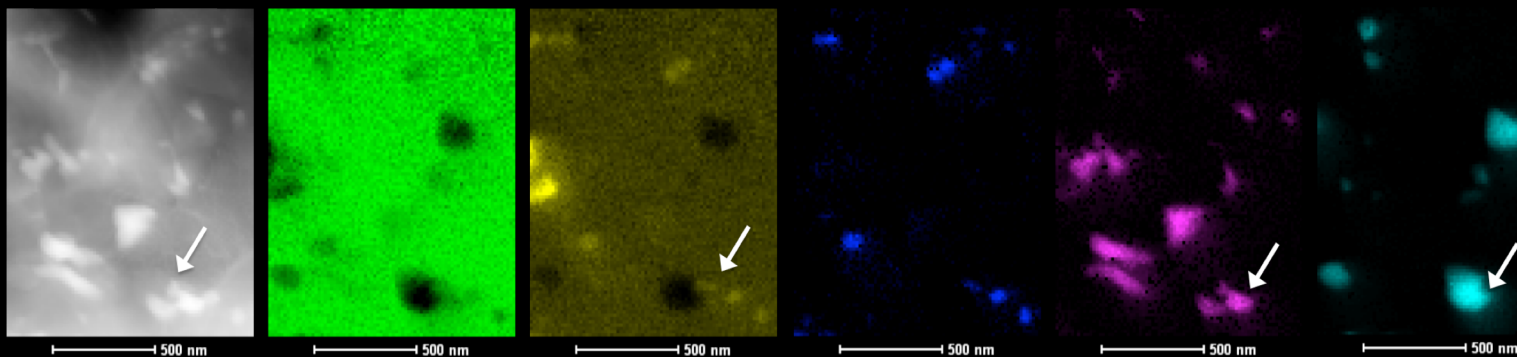


Thank you for your attention

Cu addition

	Fe	Ni	Co	Cr	W	Ta	Cu	C	B	N	Si	Mn
Z4	bal.	0.48	7.01	12.84	0.89	0.12	–	0.02	0.02	0.13	0.60	0.49
ZL1	bal.	0.99	6.22	13.00	0.76	0.12	0.89	0.02	0.04	0.23	0.58	0.58

Material	Rp (MPa)	Rm (MPa)	A5 (%)	Z (%)	Impact (J)
Z3	647	798	18.0	70.8	10.3
Z4	770	890	16.0	67.4	3.0
ZL1	-	-	-	-	46.3



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Cr

Ta

N

C

