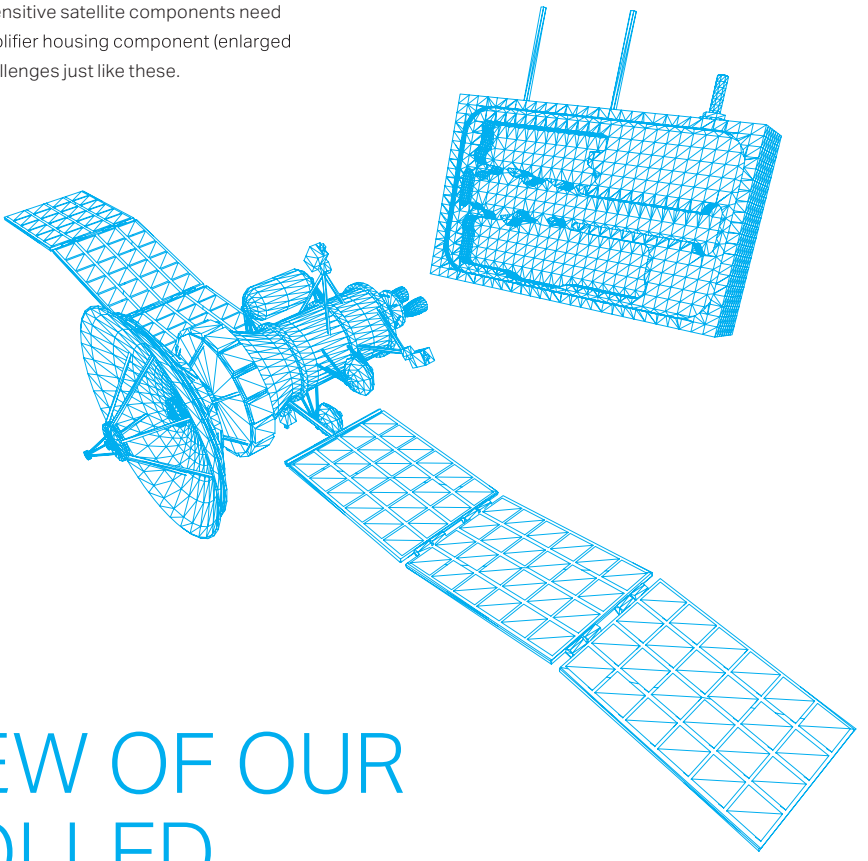
SANDVIK

OSPREY™ CONTROLLED EXPANSION ALLOY PRODUCTS ALLOYS AND PROPERTIES

TECHNICAL SPECIFICATION

Space is a typical application area for our Osprey™ controlled expansion alloy products. In cold environments, sensitive satellite components need thermal management support. The amplifier housing component (enlarged illustration) has been developed for challenges just like these.



OVERVIEW OF OUR CONTROLLED EXPANSION ALLOYS

Sandvik provides lightweight, high modulus products made from controlled expansion alloys. We manufacture according to custom design in the form of for example thermal management products and structural products for a wide range of application areas. The common denominator for these applications is that they operate in environments where demanding temperatures and variations between extreme cold and heat, create specific thermal management challenges. Typical applications are found in the space and aerospace industries, mechanical-optical, electronic housing, wafers and semiconductor equipment.

The following document contains details of the wide alloy range from which our products are manufactured. Here you can also check out the thermal as well as mechanical properties of the alloys and find out how the microstructure affects functionality of the end application.

Please contact our sales department for more details and to explore how we can design controlled expansion solutions for your particular context.

Email: cealloys.osprey@sandvik.com

ALLOYS RANGE

DESIGNATION SYSTEM

The designations for Osprey CE alloys are constructed using the following model: CE stands for Controlled Expansion. The number following after 'CE' (e.g. 7 in Osprey CE7) gives the approximate room temperature Coefficient of Thermal Expansion (CTE) in ppm/°C.

F GRADES

'F' is added to the alloy type (e.g. Osprey CE11F) to identify a finer grade than was previously available for Osprey CE alloys, that is a grade with a finer micro-structure, which improves the strength and weldability of the alloy. As the finer grades have more consistent mechanical properties without reducing the thermal properties, the F grade alloys are now substituted for all the grades of Osprey CE alloys.

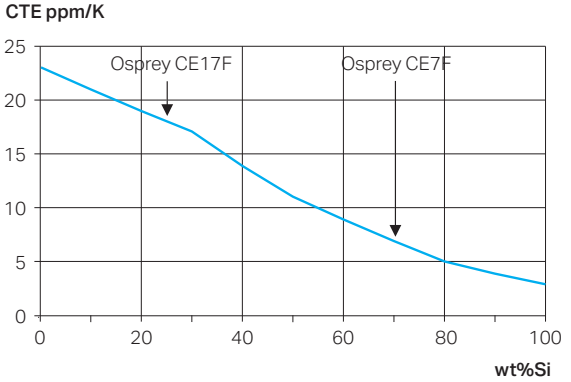
M GRADES

The M grade alloys (Osprey CE17MF and Osprey CE13MF) contain small additions of iron (Fe), manganese (Mn) and magnesium (Mg), so that similar heat treatment to 6000 series alloys (Al Si Mg) produces hardening of the matrix. Originally, this was to improve the machina-bility of the alloys but it can also be used to improve the strength, though at the expense of thermal conductivity.

STANDARD RANGE OF OSPREY CONTROLLED EXPANSION ALLOYS

Alloys	CTE
CE17F	17 ppm/°C
CE17MF	17 ppm/°C
CE13F	13 ppm/°C
CE11F	11 ppm/°C
CE9F	9 ppm/°C
CE7F	7 ppm/°C
CE6F	6 ppm/°C

Other alloys available Osprey CE8F 8 ppm/°C, CE13MF and development alloy Osprey CE5F 5 ppm/°C.



Metalised CE6F 150mm diameter LED wafer

THERMAL PROPERTIES

COEFFICIENT OF THERMAL EXPANSION, PPM/ºC (TYPICAL VALUES) OSPREY™ CE ALLOYS

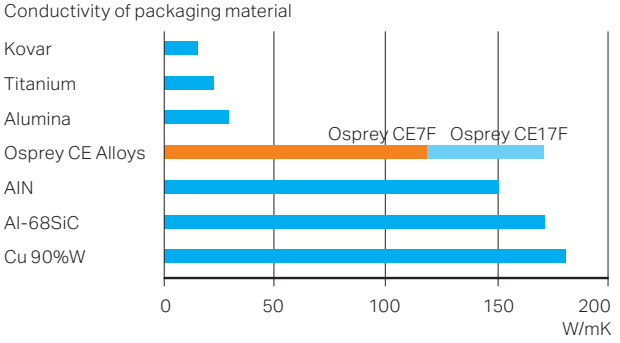
	CE17F	CE17MF	CE13F	CE11F	CE9F	CE7F
Chemical composition	Al-27%Si	Al-27%Si	Al-42%Si	Al-50%Si	Si-40%Al	Si-30%Al
100K–200K	-	-	-	7.8	-	-
200K–300K	-	-	-	10.6	-	-
100K–300K	-	-	-	9.2	-	-
-60 to +200ºC	-	-	-	11.6	-	7.6
Room temp.	15.3	15.3	12.2	11.4	9.1	7.2
25–200ºC	17.1	17.1	13.7	12.3	10.2	8.3
25–300ºC	18.1	18.1	14.6	12.9	10.9	8.8
25–400ºC	18.7	18.7	15.2	13.4	11.3	9.2
25–500ºC	19	19	15.5	13.7	11.4	9.7

THERMAL CONDUCTIVITY, W/M.K (TYPICAL VALUES) OSPREY CE ALLOYS

	CE17F	CE17MF	CE13F	CE11F	CE9F	CE7F
Chemical composition	Al-27%Si	Al-27%Si	Al-42%Si	Al-50%Si	Si-40%Al	Si-30%Al
At -100ºC	-	-	-	-	-	180
At -50ºC	-	-	-	-	1292)	140
At 0ºC	-	-	-	-	-	135
At 25ºC	177.4	146.8	145	132	121	120
At 50ºC	-	-	-	-	-	110
At 100ºC	-	-	-	-	125*	110
At 200ºC	151.2	146.5	-	-	108*	100
At 300ºC	-	-	-	-	98*	88
At 400ºC	-	-	-	-	90*	80
At 500ºC	-	-	-	-	85*	75
Specific heat, J/kgºC	846.3	767.25	857	754	780	785

Additional low temperature data is available upon request.

HIGH THERMAL CONDUCTIVITY
Thermal conductivity 120–170 W/mK

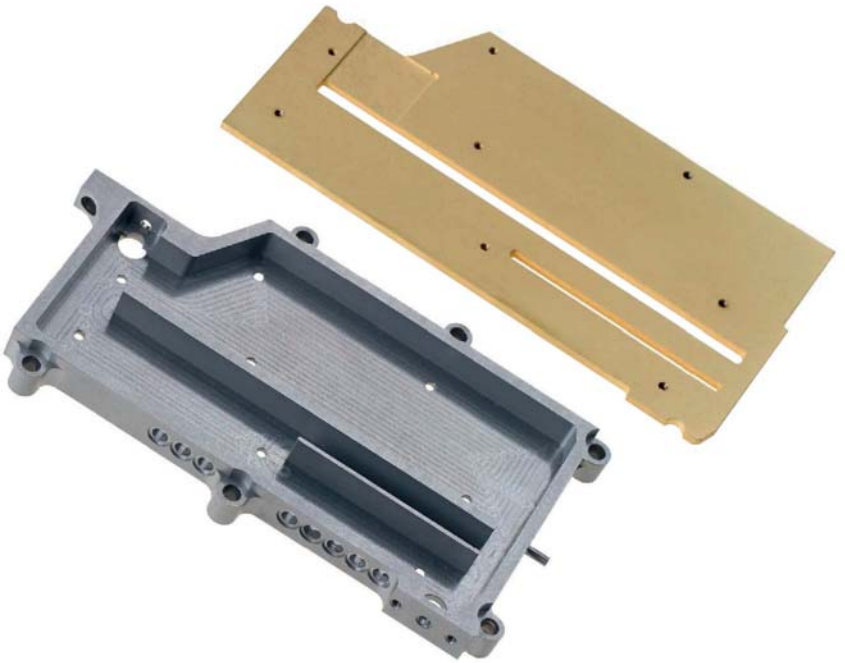


MECHANICAL PROPERTIES

MECHANICAL PROPERTIES, TYPICAL VALUES OSPREY CE ALLOYS

	CE17F	CE17MF	CE13F	CE11F	CE9F	CE7F	CE6F
Chemical composition	Al-27%Si	Al-27%Si	Al-42%Si	Al-50%Si	Si-40%Al	Si-30%Al	Si-20%Al
Tensile strength, ultimate	>160	175–312[3]	205	193	181	>100	N/A
Yield strength, MPa	100	282	147	189	-		N/A
Bend strength (three point), MPa			300	300	300	270	319[1]
Young's modulus, GPa	91.8	91.8[2]	101.9	121.4	118	129.2	130
Rigidity modulus, GPa	35.8	35.8[2]	42.2[2]	48.6	46	51.6	N/A
Poisson's ratio	0.28	0.28[2]	0.27[2]	0.29	0.29	0.26	N/A
Density, g/cc	2.6	2.6	2.55	2.51	2.47	2.43	2.35[2]
Hardness, Hv	60	75–132[3]	90	-	230	-	N/A

1) Test pieces 4 mm x 3 mm x 40 mm
2) Calculated values
3) Depending on heat treatment condition



MICROSTRUCTURE

In the molten state Si and Al are mutually soluble, whereas in the rapidly solidified condition there is minimal solubility of Si in Al (<0.3%) and even less solubility of Al in Si. The products are true alloys rather than metal matrix composites (such as AlSiC) as all the phases present originate from an homogeneous melt.

The Al phase is continuous up to ~85% Al. Over approximately 40% Si, the Si phase also becomes continuous, offering a co continuous duplex alloy (similar to AlBe alloys).

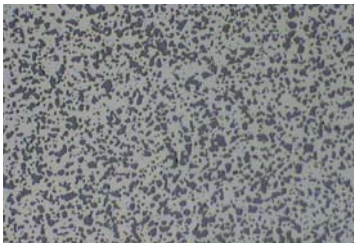
The continuous Si phase produces a stiff alloy with low thermal expansion and low internal stresses, whereas the continuous Al phase enhances thermal conductivity and toughness and lowers electrical resistance.

Consequently, as the Al content is increased, electrical conductivity, thermal conductivity, strength, toughness, CTE and machinability are also increased. For these reasons, it is best to choose the highest Al content alloy that is acceptable for the application.

Although Sandvik can supply machined components with Si contents as high as 85% Si (i.e. Osprey™ CE5), the relative brittleness of this composition means whenever feasible it is often better to compromise on the exact expansion match required and use a lower Si content alloy. For example, Kovar* packages (with a CTE of ~7 ppm/°C) have been successfully replaced with Osprey CE9F, CE11F and even CE13F.

* Kovar is a trademark of Carpenter Technology Corporation.

Osprey CE6F



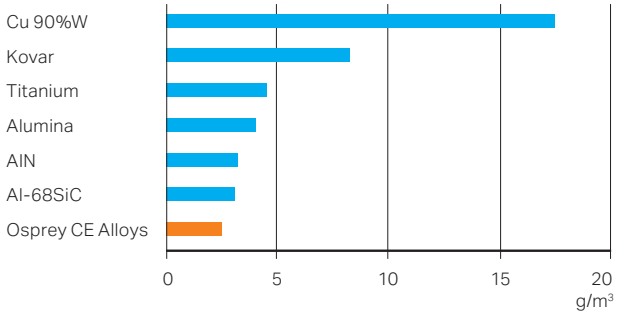
Osprey CE17F

COMPARISON WITH OTHER MATERIALS

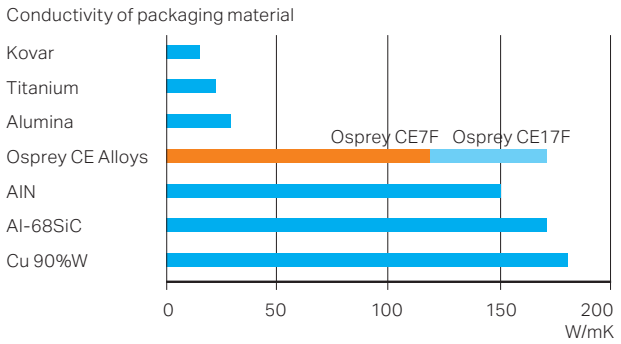
Osprey CE alloy advantages over competitive materials

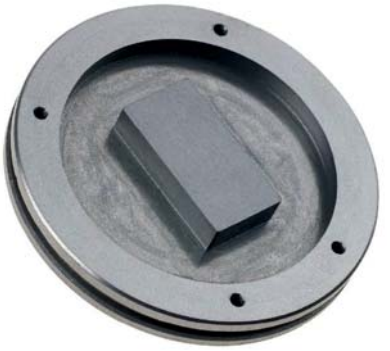
Copper 85% tungsten (CuW)	Osprey CE7F uses significantly lower cost raw materials and is 1/6 the density
Copper 85% molybdenum (CuMo)	Osprey CE7F uses significantly lower cost raw materials and is 1/4 the density
Kovar* (FeNiCo)	Osprey CE7F and CE9F housings are comparable in price but are 1/3 the density and have 6–9 x thermal conductivity, eliminating the need for heat sinks. Osprey CE7F/9F do not normally require heat treating and do not burr.
Aluminium silicon carbide (AlSiC)	Osprey CE7F and CE9F do not require mould tools, thus prototypes can be delivered quickly and with much lower setting-up costs. Osprey CE7F/9F are readily machinable and plateable.
Beryllium beryllium oxide (Be BeO)	Osprey CE alloys are environmentally friendly and non toxic.
Titanium	Osprey CE9F or Osprey CE11F are 1/2 the density and have 6x the thermal conductivity.
Aluminium alloys (e.g. 6061)	Osprey CE17F is 5% lighter, 30% stiffer and has a lower CTE than 6061 Al alloys, similar to many laminate board materials (e.g. FR4). Osprey CE17F is also less prone to burring.
Copper	Osprey CE17F is 1/4 the weight, stronger and easier to machine.
Steel	Osprey CE13F/11F have similar CTEs but are 1/3 the density.

LIGHTWEIGHT
The lightest thermal management materials commercially available



HIGH THERMAL CONDUCTIVITY
Thermal conductivity 120–170 W/mK





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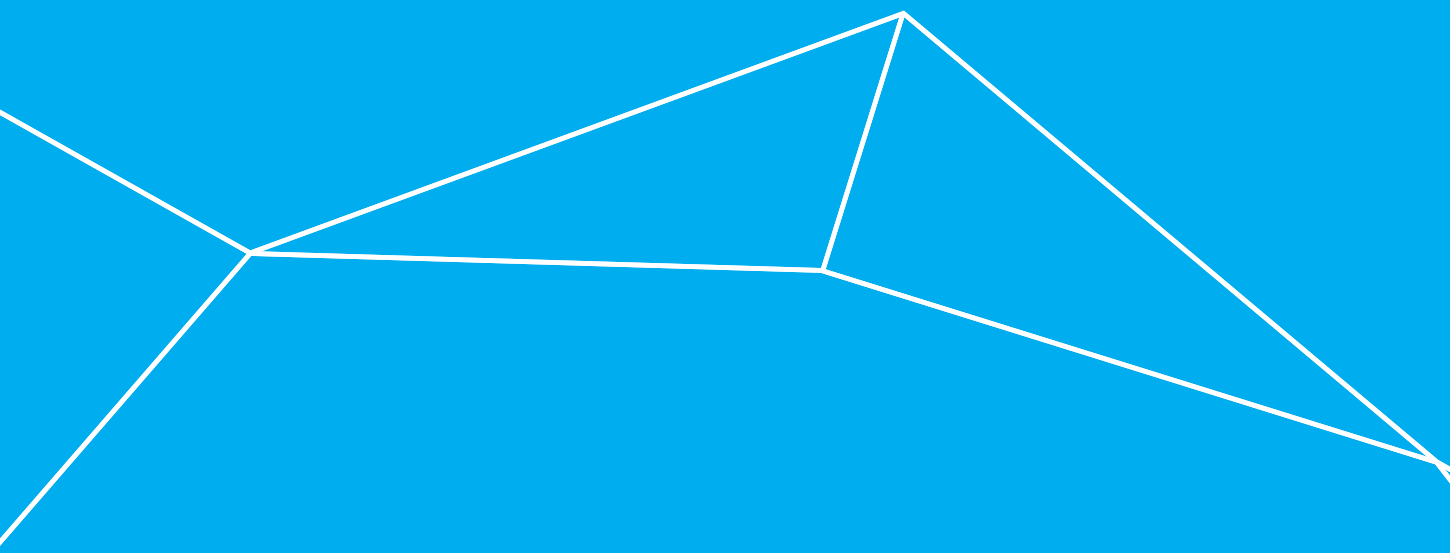

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