It has now been found that specific organopolysilazanes in combination with specific surface modified inorganic nanoparticles are useful as high refractive index encapsulation materials for light emitting diodes. Surprisingly, such materials show a lower CTE (coefficient of thermal expansion) compared to non-modified polysilazane materials and the refractive index does not change if the hybrid material is exposed to higher temperature and humidity conditions which can cause hydrolysis of polysilazane to polysiloxane.

Accordingly, ~~in one aspect of the invention~~ there is provided a hybrid material comprising

a) an organopolysilazane material, comprising repeating units of formulae (I) and (II),

$$[-SiR^1R^2 - NR^3-]_x\ [-SiHR^4 - NR^5-]_y$$

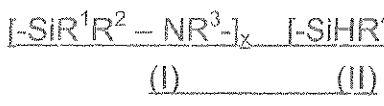
wherein the symbols and indices have the following meanings:

R^1 is C_2-C_6-alkenyl or C_4-C_6-alkadienyl, preferably vinyl or allyl, more preferably vinyl;
R^2 is H or an organic group;
R^3 is H or an organic group, preferably H;
R^4 is H or an organic group, preferably an organic group;
R^5 is H or an organic group, preferably H;
x is 0.001 to 0.2; and
y is 2•x to (1-x),
with the proviso that $x+y \leq 1$ and that y can be 0 if R^2 is H, where x and y denote the molar ratio of these repeating units with respect to the total of all repeating units Si-N in the organopolysilazane material, and

b) inorganic nanoparticles having a mean diameter in the range of from 1 to 30 nm, which are surface modified with a capping agent comprising a C_1-C_{18}-alkyl and/or C_1-C_{18}-alkenyl group.

In an aspect, there is provided a hybrid material for light emitting diodes, comprising

a) an organopolysilazane material, comprising repeating units of formulae (I) and (II)



(I) (II)

wherein the symbols and indices have the following meanings:

R^1 is C_2-C_6-alkenyl or C_4-C_6-alkadienyl;
R^2 is H or an organic group;
R^3 is H or an organic group;
R^4 is H or an organic group;
R^5 is H or an organic group;
x is 0.001 to 0.2; and
y is 2x to (1-x),
with the proviso that $x+y \leq 1$ and that y can be 0 if R^2 is H, and

b) inorganic nanoparticles having a mean diameter in the range of from 1 to 30 nm, which are surface modified with a capping agent comprising a C_1-C_{18}-alkyl and/or C_1-C_{18}-alkenyl group.

In a further ~~aspect of the invention~~embodiment of the present disclosure, there is provided a process for preparing a hybrid material of the ~~invention~~present disclosure, wherein a solution of organoypolysilazane with a dispersion of nanoparticles is mixed and the solvent is removed.

In a further ~~aspect of the invention~~ embodiment of the present disclosure, there is provided a process for producing an LED, comprising the steps of

Ia) applying a hybrid material of the ~~invention~~ present disclosure to the LED as an encapsulating layer and

Ib) curing the encapsulation material of the present disclosure~~invention~~ for 1 min to 6 h at a temperature of from 80°C to 220°C in an inert atmosphere or air.

In another aspect, there is provided a process for producing an LED, comprising the steps of

I) encapsulating the light emitting material of the LED with a hybrid material as defined above, by dispensing the material and II) curing the organopolysilazane as defined above optionally adding curing catalyst for 1 min to 6 h at a temperature of from 80°C to 220°C in an inert atmosphere or air.

In a further ~~aspect of the invention~~ embodiment of the present disclosure, there is provided an encapsulating material for LEDs, obtainable by providing an hybrid material of the ~~invention~~ present disclosure and curing the material for 1 min to 6 h at a temperature of from 80°C to 220°C in an inert atmosphere or air.

An encapsulation material for LEDs, obtainable by

a) providing a material as defined above,

b) optionally subjecting the material to crosslinking by treatment with a base, and

c) curing the material optionally adding curing catalyst by treating the material to a temperature in the range of from 80 to 220°C for a period of from 1 min to 6 h in an inert atmosphere or air.

In yet a further ~~aspect of the invention~~ embodiment of the present disclosure, there is provided an LED, comprising the hybrid material of the ~~invention~~present disclosure.

An LED, comprising the material as defined above as an encapsulation material.

In yet a further embodiment ~~of the invention~~ of the present disclosure, there is provided the use of the hybrid material of the ~~invention~~ present disclosure as an encapsulation material for LEDs.

"Hybrid material" as used herein means a material consisting of two constituents, an organic and inorganic material, the inorganic material being at the nanometer level. The hybrid material may contain additives in addition to the two constituents.

The hybrid material can act within other functions as a functional layer, e. g. optical layer or binding layer for e. g. smartphones or displays. Preferred is the use of the hybrid material as an encapsulating material as described below.

"Encapsulation material" or "encapsulant" as used herein means a material that covers the light emitting material (LED chip) and forms a barrier between the light emitting material of the LED device and the external environment of the LED device. The encapsulating material is preferably in direct contact with the light emitting material of the LED. The encapsulation material can be part of a package comprising the light emitting material and/or lead frame and/or gold wire, and/or